Digitized by the Internet Archive
in 2010 with funding from
University of Toronto

http://www.archive.org/details/chemicalengineer12newy

[illegible] Engineering
6

# Metallurgical & Chemical Engineering

A Monthly Journal, Being the Incorporation of
Electrochemical and Metallurgical Industry
and Iron and Steel Magazine

---

## Volume XII

*From January to December*, 1914

---

436837
3. 7. 45

NEW YORK
McGRAW PUBLISHING COMPANY, Inc

# INDEX TO VOLUME XII

## GENERAL ALPHABETICAL INDEX

*Entries from the Synopsis of Periodical Literature are indicated by S. (Synopsis); from the Analysis of Current Electrochemical, Chemical and Metallurgical United States Patents by P. (Patents); from the Digest of Electrochemical United States Patents Prior to July, 1902, by D. (Digest).*

## A

ABBE Engineering Co. 200
Abbe, P. O. 347
Abrasives. Allen. (P.) 533
Accountants. Cost accounting and the work of. Haynes 449, 614
——Ashby 549
ACID:
——Orthophtalic. Solubility. Rivett and Rosenblum 14
——Phosphoric. Haff (P.) 65
—— From Phosphate Rock. Washburn (P.) 533
——Sulphuric Contact process. Rittman 476
—— From smelters 440
—— Removal of Arsenic 353
—— Towers. Schliebs. (S.) 655
Acid-resisting Alloy. Gleason. (P.) 352
Acid tanks. Mastic lining 353
Addicks, Lawrence 425
Æsop at Niagara Falls 71, 214
Agriculture and Chemistry. Baekeland 564
Air Compressor. Nash 423
Air valves 232
Alaska. Development 394
Alaska Gold Company 248, 460
Alaska: Southeastern. Advantages for hydro-electrochemical industries. Lass 337
Alby United Carbide Factories 34
ALLOYS:
——Acid-resisting. Gleason. (P.) 352
——Aluminium. McAdams. (P.) 352
——Binary. Rapid Cooling. Gulliver. (S.) 595
—— Argental and macademum 360
—— Ormiston 649
——Babbitt Metal. Determination of Copper 753
——Bronze. Dewrance. (S.) 594
——Bronze. Three-metal Blow 461
——Bureau of Standards Analyzed Brass Samples 80
——Copper - Aluminium. Read and Greaves. (S.) 595
——Copper-Rich Kalchoids. Hoyt 30
——Copper, Tin and Zinc. Hoyt 644
——Definition. Thatcher 430
——German Silver. Metallography. Thompson 785
——Gun Metal. Effect of temperature 597
——Heating in Vacuo. Thorneycroft and Turner 787
——Iron and Steel Hadfield 598
——Iron-Nickel-Copper. Clamer. (P.) 413
——Manganese Bronze Corse 113
——Manganese bronze Skillman and Corse 113
——Melting points of copper alloys 102
——Muntz Metal Stead and Stedman. (S.) 596

ALLOYS: (Continued.)
——Platinum and tungsten and molybdenum. Weintraub 475
——Pyrophoric. Faebr. (P.) 660
—— Patent Decision 218
——Tungsten and Nickel. Kressler. (P.) 728
Alumina. Determination in iron ores. Wurzel 430
ALUMINIUM:
——Alloys argental, macadamum 360
——Alloy. McAdams. (P.) 352
——Alloy. Ormiston 649
——Alloys with Copper. Read and Greaves. (S.) 595
——Calorizing 730
——Density. Brislee 14
——Electroplating upon. Loeb. Mies. (D.) 800
——Light Strong Castings 619
——Ore production 290
——Precipitant for Cyanide Solutions. Butters. (S.) 351
——Purifying. Mellen. (P.) 352
——Solder. (P.) 66, 352
——Wire. Electrolytic insulation. Chubb and Skinner 712
Alundum. High-Temperature Resistivity. Northrup 125
Amalgamating in cyanide solutions. Randall 248
——See also Gold and Silver.
Amalgams of Sodium. Electric Conductivity. Nanstone 14
Amberg, Dr. Richard 485
American Bottle Company 440
American Bridge Co. 165, 355
American Chemical Society 360, 494
——Montreal Meeting Postponed 550
——New York Section. Chemical and Dyestuff Committee Report 753
American Clay Company 440
American Cyanamid Company. Niagara Works 265
American Electrochemical Society 221, 368, 419, 514, 619
——New York meeting. Report 327
——Niagara Falls Convention. Report 703
——New York Section 419
American Foundrymen's Association 550
——Chicago Convention 641
American Gas Institute. Chemical Section 677
American Institute of Chemical Engineers. New York meeting 55
——Philadelphia Meeting 756
——Troy Meeting 376, 434
American Institute of Metals 550, 588
——Chicago Convention 641
American Institute of Mining Engineers 189, 296, 304, 366, 416, 514
——Utah Meeting 589
American Iron and Steel Co. 62
American Peat Society 788
American Platinum Works 360

American Rapid Cyaniding Co. 734
American Rolling Mill Co. 424
American Smelting & Refining Co. 194, 212, 288
American Zinc, Lead & Smelting Co. 432
AMMONIA:
——Analysis. Stach. (S.) 655
——From Calcium Cyanamide. Cooper. (P.) 480
——From Coal Gas 699
——Synthesis 477
——Ammonia process for zinc and copper ores. Bretherton. (P.) 139
——Ammonia soda process. Theory. Mason 571
Anaconda Copper Mining Co. 432
Anaconda-International Consolidation 366
Anaconda. Model Town 618
Anaconda. Progress in Metallurgy 737
Analcid Method 793
ANALYSIS:
——Ammonia. Stach. (S.) 655
——Analoid Method 793
——Calorimetric of Gold in Cyanide Solutions 460
——Carbon in iron and steel. Brown 390
——Chromium in iron and steel. Walters. 310
——Coal in U. S. 62
——Copper in Babbitt Metal. Hagmaier. 753
——Electrometric titration. Ziegel 705
——Fine-meshed Brass Gauge as Substitute for Platinum in Electro-analysis 87
——Gas 677
——Gold and Platinum Assay. (S.) 480
——Grading by Elutriation. Stadler. (S.) 536
——Lead determination at Broken Hill. (S.) 54
——Natural gas. Brown 168
——Nickel, Marsh 709
——Phosphorus in phosphor bronze. Hagmaier 524
——Phosphorus in Scheelite Concentrates. Hagmaier 620
——Radium. Schlundt 709
——Silica and alumina in iron ores. Wurzel 430
——Tin Ores and Concentrates.
—— Hutchin. (S.) 350
—— Wraight and Teed. (S.) 350
——Zinc determinations at Broken Hill 138
——Zinc in Bronze Coins. Rose 326
Annealing Brass and German Silver Wire. 483
Annealing malleable castings. Storey 383
Anticorrosion lead oxide deposit (D.) 543
Anticorrosive Magnetic Oxide Deposit. 425, 736
Anti-Corrosive Pickling Chains and an Acid-pump Casting 206
Antimony. Metallurgy. Cowan 643
Anyox Smelter 676
Apparatus for Determining the Hardness of Metals by the Brinell Method. 205

Appleby, William R. .... 735
Arc light with unconsumed electrodes. Vosmaer .... 377
Argental .... 360
Arizona Copper Co. ...34, 104, 222, 269, 684
Arizona Copper Smelter. Unit Construction Cost. Jones. (S.) .... 653
Arizona. New Copper Smelter .... 11
Arms and the Man .... 488
Arsenic. Removal from sulphuric acid .... 353
Asbestos. Uses in Chemistry and Metallurgy .... 356
Ashland Fire Brick Co. .... 580
Askenasy, Prof. Paul .... 485
Atomic Weight. Indefiniteness. Fajans and Hönigschmid .... 495
Atomic Weight of Lead .... 487
Atom. Structure, and high-frequency spectra .... 363
Auld Company .... 541
Aurora Consolidated ....493, 556
Austin, A. Obituary .... 542
Austin, J. F. .... 542

B

BABBITT metal. Determination of Copper. Hagmaier .... 753
Badger & Sons Co., E. B. .... 360
Badger Chemical Diary .... 360
Bag House in Lead Metallurgy. Anderson. (S.) .... 654
Baekeland, Leo H. .... 541
Baer, W. P. .... 426
Bailey, Gilbert E. .... 475
Baily, T. F. .... 141
Bakelite for Commutator Insulation .... 603
Baker & Co. .... 360
Baker Suspension Bin .... 120
Bamberger, Ernst .... 799
Bancroft, W. D. Portrait .... 335
Barber Asphalt Paving Co. .... 258
Baron, H. J. .... 799
Barrows .... 46
Baryte in California .... 722
Barytes. Separation from Zinc Blende. Greenstreet. (P.) .... 659
Bath processes for wood waste. Teeple .... [illegible]5
Battery. Railway Track Cell. Marshall .... 342
Bayonne Bolt & Nut Company .... 4[illegible]
Beer. Chill-proof. Patent suit .... [illegible]
Benzol from Coal Gas .... 702
Bethlehem Steel Company .... 306
Bicarbonate of soda and sawdust for extinguishing fires .... 105
Biddle Hardware Co. .... 68
Bins for blast furnaces. Design .... 117
Bin. Suspension Storage. McKee .... 605
Bismuth from Copper. Thum. (P.) .... 479
Bismuth. Nitric Acid Treatment .... 583
Bitumen and electric mains explosions .... 80
Blair, Robert S. .... 735
Blake, Lucien I. .... 541
BLAST FURNACE:
—Blowers. McQuigg .... 286
— Johnson ....230, 311
—Bosh. Lead. Anderson. (S.) .... 782
—Flue Dust Handling. (S.) .... 481
—Flue Dust. Nodulizing. Addicks. (S.) .... 654
—Flue dust. Baggaley. (P.) .... 139
—Gas cleaning and utilization. Johnson ....685, 760
—Heat Balance. Cornell .... 747
—Lead. Palmer. (S.) .... 654
—Oil-fired. Copper .... 492
—Stack. Shannon. (P.) .... 351
—Use of raw fuel. Prudhomme. (P.) 351
—See also Iron and Steel.
Blaugas. Manufacture and use. Lieber .... 153
Blowing Engines. Gas .... 734
Blowpiping, quantitative, as aid to prospector. Fischer ....693, 771
Boiler Plant for Blast Furnace. Johnson. 171
Boilers. Prevention of Scale .... 180
BOOK REVIEWS:
—American Fertilizer Hand Book .... 544
—Aubert & Rogers. Industrial Chemistry .... 211
—Brame, J. S. S. Fuel, solid, liquid and gaseous .... 800
—Carrier. Engineers' Handbook of the Buffalo Forge Company .... 486
—Classen. Quantitative Analysis by Electrolysis .... 212
—Gowland. Metallurgy of the Non-Ferrous Metals .... 668
—Hall. Steel Foundry .... 486
—Heather. Electrical Engineering for Mechanical and Mining Engineers .... [illegible]1
—Hooker. Chloride of Lime in Sanitation .... [illegible]11
—Hoover, L. H., & Hoover, H. B. Agricola's De Re Metallica .... 14[illegible]
—Johnson. Chemical Analysis of Special Steels .... 668
—Keeney & Lyon. Electric Furnaces for Making Iron and Steel .... 544
—Kindl. Rolling Mill Industry .... 544
—Liebig. Zink und Cadmium .... [illegible]0
—Lyon and Keeney. Electric Furnaces for Making Iron and Steel 544
—Mennicke. Die Quantitativen Untersuchungsmethoden des Molybdäns, Vanadiums und Wolframs .... [illegible]

BOOK REVIEWS. (Continued.)
—Mineral Industry. Edited by G. A. Roush .... 736
—Müller. Elektrochemisches Praktikum 610
—Noble. Fabrication de l'Acier .... 610
—North. Laboratory Experiments in General Chemistry .... 211
—Rogers & Aubert. Industrial Chemistry .... 211
—Stansfield. Electric Furnace .... 212
—Wagner. Cleaning of Blast Furnace Gases .... 800
—Weed. Copper Handbook .... 426
—Wren. Organometallic Compounds of Zinc and Magnesium .... 544
Borax .... 661
Borchgrevink Process .... 381
Boron. Weintraub .... 185
Boyer, F. T. .... 609
Brackett & Co., F. W. .... 799
Bradley, Fred W. .... 799
BRASS:
—Bureau of Standards. Analyzed Samples .... 80
—Corrosion. Whyte and Desch. (S.) 595
—Corrosion. Influence of Coke... 724, 787
—Economy of electric melting. Gillett and Lohr .... 647
—Electric Brass Melting from Central-Station Viewpoint. St. John .... 646
—Electric Furnace. Helberger. Dorsey 644
—Electric Melting with Hering furnace. Clamer and Hering .... 648
—Electrolytic deposition of. Bennett and Davison .... 340
—Fine Meshed as Substitute for Platinum in Electroanalysis .... 87
—Furnace Practice .... 540
—Pyrometers for molters. Gillett .... 648
—Resistivity, solid and molten. Northrup .... 161
—Use of gas in melting .... 648
—Vanadium in. Dunn and Hudson. (S.) .... 594
Brick, Silica and Clay. Relative thermal conductivity. Marshall .... 74
Brick, Paving, from Blast Furnace Slag 43
Bridgeport Testing Laboratories .... 66
Brinell hardness. Derihon apparatus .... 205
Briquets. Channel Furnace for burning. Rameo. (P.) .... 353
Briquets. Coal .... 360
Briquetting Fine Ore. Methesius. (P.) .. 657
Briquetting Iron Ores. Crusius. (P.) .... 788
Briquetting. Ronay. (P.) .... 262
Bristol Co. ....208, 357, 605, 797
British Aluminium Co. .... 394
British Geological Survey .... 448
British Westinghouse Co. .... 325
BRONZE:
—Determination of phosphorus in phosphor bronze. Hagmaier .... 524
—Determining Zinc in Bronze Coins .... 326
—Dewrance. (S.) .... 594
—Manganese. Corse .... 113
—Manganese. Skillman .... 113
—Pyrometers for molten. Gillett .... 648
—Three metal. Blow .... 461
Brown Hoist Bins .... 118
Brown Hoist Machinery .... 48
Brown Instrument Co. .... 208
Bruce, Stuart S. .... 667
Buffalo Forge Co. .... 171
Buffalo Mines Co. .... 493
Bunker Hill & Sullivan Mining Co. .... 258
Bunsen Society, German. Leipzig meeting .... 495
Burch, Albert .... 541
Bureau of Mines. .62, 78, 150, 198, 366, 436, 460, 540, 678
—New Buildings at Pittsburgh .... 311
—Policy. Holmes .... 334
Bureau of Standards .... 588
—Analyzed Samples .... 80
Burgess, C. F. .... 277
Burner. Dunn Powdered Coal .... 94
Burro Mountain Copper Co. .... 288
Busch-Sulzer Bros. Diesel Engine Co. .. 347
Butte and Superior ....99, 222, 618
Butters, C. ....268, 277
Butz, H. A. .... 735

C

CADMIUM. Electrodeposition. Marble and Mathers .... 339
Cadmium in glass. Sullivan .... 188
Calcium carbide. Alby Factories .... 34
Calcium carbide. Pure. Preparation. Thompson .... 779
Calcium cyanamide. Landis. (P.) .... 53[illegible]
Calcium cyanamide. Niagara Works .... 265
Calcium Cyanamide. For Ammonia Production. Cooper (P.) .... 480
California. Chemical resources in. Dolbear .... 720
California. Mineral output .... 422
Callon, J. M. ....141, 541, 609
Calorimeter. Adiabatic. Riche .... 606
Calorimeter. Fery Gas .... 650
Calorimeter. Recording Gas .... 662
Calorimeter. Recording. Stone and Hinman .... 6[illegible]8
Calorizing .... 730
Calumet & Hecla .... 556
Cameron, Angus .... 141
Camp Bird .... [illegible]7, 744
Carbon Electrodes. Skin Effect. [illegible] 223
Carbon. Energy of vaporization. Hering [illegible]
Carbon, Granular, Calcination and graphite production. Brown. (P.) 727
Carbon, [illegible]. Tone .... 710
Carbon tetrachloride for extinguishing fires .... 105
Carnegie, Andrew .... 43
Carnotite concentration. 14[illegible], 365, 89, 146, 36[illegible]
Carnotite in Utah .... 49[illegible]
Carnotite, Prospecting .... 15[illegible]
Carnotite, Radium to Uranium Ratio in Carnotite (S.) .... 65[illegible]
Carveth, Hector R. .... 60[illegible]
Castings, Electric steel. Hansen .... 335
Castings, Study of the annealing process for malleable. Storey .... 383
Castner Electrolytic Alkali Co. .... 419
Caustic and chlorine. Mercury cathode. Le Sueur .... 61
Caustic soda by electrolysis. Diaphragm cell. Dow (P.) .... 480
Caustic soda. Diaphragm cell. Byrnes (P.) .... 534
Cell, Primary. Effect of alternating current .... 264
Cell, Railway track. Marshall .... 342
Celluloid. Absorption of gases .... 180
Celluloid. Hyatt .... 13[illegible]
CEMENT:
—Chemistry of salt water cement. Taft ....26, 27
—Portland. Testing. (P.) .... 194
—Thomas Mellen Co. .... 104
—Production in 1913 .... 198
—Recovery of dust from kilns. Carpenter and Fleming (P.) .... 66
—Testing. Gadd .... 130
Chain Belt Company .... 543
Chain belt. Steel .... 543
Chain drive. Sileot .... 347
Chandler Foundation Lecture. Frost. Baekeland ....427, 446, 557
Channing, J. Parke .... 485
Chapman Engineering Co. ....206, 440
Chart recording instrument .... 208
Chase, C. A. .... 210
Chemical and dyestuff industry 55[illegible], 679, 684, 75[illegible]
Chemical industries as affected by characteristics of electrical energy. Steinmetz .... 329
Chemical industries. Effect of legislation. Wagner .... 15
Chemical industry in Russia .... 104
Chemical industries of U. S. and the war. Nichols, Toch, Matheson, Hesse, Mattos .... 551
—Stone .... 679
Chemical industries of U. S. Chemical and Dyestuff Committee report 753
Chemical resources of California. Dolbear .... 720
Chemical versus physical actions in furnaces. Hering .... 439
Chemistry. The dependence of industries on. Pierce .... 614
Chemistry. Industrial Aspects of. Baekeland .... 55[illegible]
Chemistry in America .... 66[illegible]
Chemistry. Industrial. Some economic aspects. Hesse .... 594
Chemistry. Manufacturing possibilities [illegible]1
Chemistry. Physical. Application to industrial processes. Rittman .... 4[illegible]5
Chemists' Club. Presentation of bronze bust of Morris Loeb. .... 220
Chemists' Club. Tango .... 283
Chemists. Professional obligations. Whitaker .... 43[illegible]
Chemists' slide rule. Lee .... 2[illegible]
Chile, Chuquicamata. Development of copper leaching and electrolytic precipitation. Smith .... 29[illegible]
Chino Copper Co. .... [illegible]
Chlorate of potash in Norway .... 576
Chloridizing ores at Silver City, Utah [illegible]
Chloridization of ores. Dry. Malm .... 128
Chloridizing roasting. Ledoux (P.) .. 14[illegible]
Chloridizing sulphide ores. Forland (P.) . [illegible]4
Chlorination of ores. Christensen and Holt. (P.) .... 65[illegible]
Chlorination at Park City .... 431, 4[illegible]
Chlorination in Utah .... 22[illegible]
Chlorine and caustic. Mercury cathode. Le Sueur .... 6[illegible]
Chlorine by electrolysis. Diaphragm cell. Dow (P.) .... 48[illegible]
Chlorine. Diaphragm cell. Byrnes (P.) 534
Chlorine for detinning. Von der Linde. (P.) .... [illegible]90
Chlorine. Production and products. Baekeland .... 56[illegible]
Chrome ore in California .... 72[illegible]
Chromium. Determination in iron and steel. Walters .... 31[illegible]
Church, John A. .... 45[illegible]
Cie des Forges & Aciéries Électriques Paul Girod .... [illegible]
Clam shell filter press. Sweetland .... 5[illegible]
Clark, H. C.
Clark, William W. .... 66[illegible]
Classics. Quotations from .... 216
Clay brick and silica brick. Relative thermal conductivity. Marshall .... [illegible]4
Cleaning laundry work. Electrolytic (P.) .... 60[illegible]

Clennell, J. E. .... 141
Close, Fred .... 541
Coal analysis in U. S. .... 62
Coal briquets .... 360
Coal. Carbonization. Harger .... 264
Coal gas residuals. Wagner .... 696
Coal. Powdered. Burner for. Dunn, Roush .... 19
Coal. Powdered. Burner for. Dunn.
Coal. Pulverized. Lord. (S.) .... 53
Coal tar colors in America. Stone .... 679
Coal tar industry and the war. Matheson, Hesse, Matos .... 552
Cobalt, Ont., Canada. Ore treatment. Parmelee .... 467, 507
Cobalt and alloys. Kalmus .... 184
Cobalt. Separation from copper and nickel. Hybinette. (P.) .... 531
Cobalt-silver ores. Dyckerhoff. (P.) .... 412
Collins, George E. .... 609
Colorado Iron Works Co. .... 420
Colorado metal production in 1913 .... 539
Colorado School of Mines .... 222, 269
Colors. Coal tar in America. Stone .... 679
——Matheson, Hesse, Matos .... 551
Colors, Mineral, in California .... 722
Color photography of microstructure of ores. Rigg .... 30
Columbia University .... 295
Columbia University. School of Mines. 50th anniversary .... 168, 347
Combustion. Flameless or surface. Bone. 325
Commutator insulation. Bakelite .... 603
Compass. Gyroscopic. Scott and Rozie. 786
COMPLEX ORE PROBLEM:
——Austin .... 300
——Bell .... 297
——Bleecker .... 375
——Bretherton .... 374
——Canby .... 301
——Choate .... 430
——Clerc .... 471
——Clevenger .... 298
——Collins .... 298
——Croasdale .... 369
——George .... 373
——Godbe .... 302
——Godshall .... 471
——Guess .... 300
——Haldane .... 374
——Hoskin .... 372
——Ionides .... 375, 674
——Johnson .... 370
——Monell .... 490
——Motherwell, H. .... 549
——Motherwell, W. .... 490, 549, 673
——Parks .... 370
——Richards .... 370
——Scibird .... 373
——Skinner .... 371, 548
——Swart .... 297
——Thomson .... 371
——Traphagen .... 300
——Wiard .... 301
——Editorial summary .... 472, 555
Compressed air for lifting solutions in quantity. Phelps .... 391
Compressing air and gases. Nash .... 423
Compressors. Gas-engine driven .... 743
CONCENTRATION:
——Carnotite .... 365
—— Fischer .... 146
—— Kithill and Moore .... 89
——Complex sulphides from Mary Murphy mine. Collins .... 243
—— Parmelee .... 21, 217
—— Keedy .... 157
——Development of methods in 1913 .... 5
——Dry concentration and flotation at Joplin .... 492
——Dry jigging unsized ore .... 555
——Electrostatic separation. Wentwood. (S.) .... 782
——Flotation and cyaniding .... 221
——Flotation antimonial silver ore. Campbell. (P.) .... 198
——Flotation litigation decision .... 362, 366
——Flotation of lead and copper ores .... 77
——Flotation. Minerals Separation Co. 77
——Flotation. Oil. At Butte and Superior .... 222
——Flotation. Selective Horwood process. (S.) .... 350, 414
——Igneous of metallic values from mixed sulphides. Clerc..250, 307, 490
——Isbell concentrator for unsized or unclassified ore-pulp .... 601
——Magnetic separator. Ulrich. (S.) .. 536
——Old tailings. Silver Lake .... 11
——Round table at Great Falls. Crowfoot. (S.) .... 783
——Tin at Geevor Mill, Cornwall, (S.). 262
Condenser tubes. Corrosion. Bate. (S.). 656
Conduction. Electric. At high temperatures. Northrup .... 340
Congress. International engineering .... 11
Congress. International, of Mining, Metallurgy, Engineering and Economic Geology .... 392
Congress. International, of Tropical Agriculture .... 101
Conklin, H. R. .... 69
Consolidated Ores Co. .... 493
Contact process for sulphuric acid. Rittman .... 476
CONVERTER:
——Basic copper Magnetite linings. Wheeler and Krejci. (S.) .... 138
——Basic lined copper at Old Dominion. Howard. (S.) .... 654
CONVERTER: (Continued.)
——Bessemer. Bretand. (P.) .... 529
——Copper. Haas. (S.) .... 535
——Copper matte. Herreshoff. (P.) .... 728
——Lead matte at Tooele. Kuchs. (S.). 654
——Tropenas vs. electric furnaces for the manufacture of steel castings. Muntz .... 379
Converting copper. Improvements .... 144
Converting. Cost of power for air .... 537
Conveyors. Weighing the continuous flow of materials .... 206
Cooler for roasted ore. Hanington. (P.). 791
Cooler. Ore. Laist. (P.) .... 352
Cooper Co., C. & G. .... 743
COPPER:
——Alloys with aluminium. Read and Greaves. (S.) .... 595
——Alloy with nickel and copper. Clamer. (P.) .... 413
——Alloys with tin and zinc. Hoyt .... 644
——Ammonia process. Bretherton. (P.). 139
——Analysis in Babbitt metal. Hagmaier .... 753
——Basic-lined converter practice at Old Dominion. Howard. (S.) .... 654
——Basic-lined copper refining furnace. Addicks and Brower. (P.) .... 195
——Bessemerizing. Matte - Herreshoff. (P.) .... 728
——Butte and Duluth. Costs .... 269
——Cathode. Reproducibility of. Getman 706
——Chloridizing leaching at Park City. Holt .... 593
——Combination smelting and converting furnace. Knudson. (P.) .... 64
——Converter. Haas. (S.) .... 535
——Converting. Improvements in .... 144
——Copper-nickel ore treatment. Borchers and Pedersen. (P.) .... 659
——Copper-tin, copper-zinc, copper-phosphorus and copper-aluminium alloys. Blow .... 461
——Copper-tin-lead alloys. Blow .... 462
——Effects of repeated remelting. Clements .... 644
——Electrolytic production of flat perforated copper tubing for radiators. Feldkamp .... 67
——Electrolytic process. Frasch. (D.) .. 142
——Extraction from large boulders. Craney. (D.) .... 142
——Factors affecting the cost .... 379
——Filtration of flue dust from furnace gases. Rigg. (P.) .... 531
——Flotation of lead and copper ores .... 77
——From carbonate and oxide ores. Ellis. (P.) .... 788
——Fuel in reverberatory smelting. Demond. (S.) .... 781
——Heating leaching solutions. Laist. (P.) .... 788
——Hydrometallurgy .... 150
—— Goodrich .... 338
—— Laist. (P.) .... 63
—— Mackay. (P.) .... 63, 412
—— Weidlein. (P.) .... 260
——Hydrometallurgy at Chuquicamata .. 279
—— Smith .... 291
——Impurities in cathode. Addicks .... 706
——In Scotland .... 448
——Kalchoids. Hoyt .... 30
——Leaching copper tailings. Gahl .... 338
——Leaching with Dorr classifiers at Butte and Duluth. (S.) .... 481
——Leaching. Laist and Aldrich .... 589
——Leaching of Ajo ores. Croasdale .... 591
——Leaching at Steptoe works. Austin. 590
——Melting points of copper alloys .... 103
——Microstructure of raw and manufactured. Motherwell .... 8
——Monolithic magnetite linings for basic copper converters. Wheeler and Krecji. (S.) .... 138
——New smelter for Arizona .... 11
——Nodulizing blast-furnace flue dust. Addicks. (S.) .... 654
——Oil-fired blast furnace .... 492
——Oxide and carbonate ores. Treatment with nitric acid. Bueler .. 583
——Parral tank system for leaching copper ores .... 141
——Power problem in electrolytic refining of. Addicks .... 91
——Precipitation from solution at Anaconda. Laist and Frick .... 589
——Production by Nevada Consolidated, China and Utah companies .... 150
——Progress in metallurgy in 1913 .... 2
——Reducing cuprous chloride. Laist. (P.) .... 659
——Refined. Commercial classification. Addicks .... 641
——REFINING:
—— Anode residue, gold and silver. Treatment. Keller. (P.) .. 728
—— Apparatus. Elliott and Kishner. (D.) .... 210
—— Circulation of electrolyte in refinery. Dunton. (D.) .... 70
—— Copper-nickel alloys. Browne. (D.) .... 211
—— Electric cranes used .... 729
—— Elmore. (D.) .... 69
—— Impurities in cathode copper. Addicks .... 706
—— Klepetko and Morrow. (D.) .. 142
—— Melting cathode copper in electric furnace. Lyon and Keeney. (S.) .... 781
COPPER: (Continued.)
—— Metal inventory in an electrolytic refinery. Deacon .... 338
—— Nickel-ferrous copper. Ulke. (D.) .... 210
—— Purification of electrolyte. Smith. (D.) .... 70
—— Roasting precious-metal residue. Wales. (P.) .... 412
—— Thum. (D.) .... 70
—— Walker. (D.) .... 210
——Round table at Great Falls. Crowfoot. (S.) .... 783
——Roasting copper-nickel matte. Kern and Merris. (P.) .... 198
——Separation of Bismuth. Thum. (P.) 479
——Separation of copper from nickel and cobalt. Hybinette. (P.) .... 531
——Slime-concentrating plant at Washoe works. Laist and Wiggin .... 593
——Smelting in Nevada .... 77
——Sound castings. Spinney. (P.) .... 412
——Tensile properties at high temperatures .... 786
——Unit construction cost of Arizona copper smelter. Jones. (S.) .... 653
——See also complex ore problem.
——Welding with nickel .... 619
Copper Queen Consolidated Mining Co. .. 288
Corrosion. Brass. Whyte and Desch. (S.) .... 595
Corrosion. Brass. Influence of coke, 724, 787
Corrosion. Condenser tubes. Bate (S.). 656
Corrosion. Iron. Effect of pickling. Richardson .... 759
——See also anticorrosive.
Corse, W. M. .... 141
Cost keeping. Unit cost in metallurgical works. Haynes .... 449, 614
——Ashby .... 549
Cost. Unit construction. Arizona copper smelter. Jones. (S.) .... 653
Cottrell, F. G. .... 209
Craft, cunning and intelligence .... 429
Crabtree, Frederick .... 343
Craig, Norman .... 609
Crane. Electric, for handling long iron rods .... 482
Crane. Electric. In copper refineries .. 729
Cranes. Locomotive .... 798
Croasdale, Stuart .... 609
Crocker, Francis B. .... 485
Crowley Co., John A. .... 209
Crushing. Laws of .... 143
Crushing. Theory. Taggart. (S.) .... 262
Crushing. Kick's law. Speak. (S.) .... 481
Crushing. Laws of Kick and Rittinger. (S.) .... 783
Crushing. Fine ore with Nissen stamps. (S.) .... 198
Cunning, craft and intelligence .... 429
Cupellation. Detection of platinum in gold-silver cupellation beads. (S.) .... 137
Curran, T. F. V. .... 421
Cutting. Oxy-acetylene .... 66
CYANIDE:
——Consumption in U. S. and Canada .. 743
——Determination of free cyanide in electroplating solutions. Lundell 340
——Cyanogen from coal gas .... 699
——From coal gas. Tutwiler. (S.) .... 785
CYANIDE PROCESS:
——Aluminium precipitation. Butters. (P.) .... 351
——Amalgamating. Randall .... 248
——Brown cyanide patent decision .. 219, 286
——Calorimetric estimation of gold in cyanide solutions .... 460
——Chaffer's mill. Kalgoorlie. (S.) .... 783
——Cleaning filter leaves with Lactic acid. Leach. (P.) .... 530
——Continuous slime thickening apparatus. Rothwell. (P.) .... 479
——Cost accounting .... 449, 549, 614
——Custom cyanide mills .... 72
——Development of modern practice. Eye .... 392
——Dome mill. Porcupine. Forbes. (S.) .... 349
——Filter leaf. Butters. (P.) .... 65
——Filter leaf. Shepherd. (P.) .... 479
——Fine grinding on the Rand. (S.) .. 414
——Flotation and cyaniding .... 221
——Granulated zinc precipitation. Urquhart. (P.) .... 351
——Grinding ore .... 611
——Grinding ore. A suggested modification for all-sliming practice. Dorr .... 672
——Grinding ore. Modification for all-sliming practice. Pentland ... 621
——Historical review. Mulholland. (S.) 263
——Mercur district, Utah .... 12
——Motherlode Sheep Creek mill .... 492
——Nipissing practice. (S.) .... 348
——Nipissing mill. Clevenger. (S.) .... 653
——Porcupine district. Parmelee ... 567, 636, 674, 742
——Precipitation of metals. Ross. (P.) 530
——Preparation of refractory ores for cyaniding. Butters. (P.) .... 658
——Rapid cyanidation. Reinohl .... 734
——Rochester Mines Co. .... 677
——Sand leaching at Oroya Black Range. (S.) .... 414
——Silver Sulphide ores. Linton. (S.) 349
——Slime agitator. Marcy. (P.) .... 195
——Slime filter. Minder (P.) .... 195

CYANIDE PROCESS: (Continued.)
——Slime filter. Butters. (P.) ....... 530
——Slime filter. Drage. (P.) ....... 260
——Slime filter. Ridgway. (P.) ....... 659
——Slime filter. Trent. (P.) ....... 658
——Smelting furnace for cyanide precipitate ....... 492
——Synthetic production of sodium cyanide. Matignon ....... 163
——Tube milling in all-slime practice. Pentland ....... 750
——Unit cost keeping. Haynes.....449, 614

## D

DALY West Mining Co. ....... 733
Davis, T. H. ....... 799
Davis-Bournonville Co. ....... 66
Dearsenicator. Davis ....... 353
De Laval Separator Company ....... 576
Denton, Frederick W. ....... 485
Denver Engineering Works Co.....496, 601
Department of Commerce ....... 440
Department of Mines ....... 220
de Pass, George ....... 609
Desulfurization. Hall process ....... 718
Detarring. Gas. Steere ....... 677
Detinning. Savage. (P.) ....... 790
Detinning. von der Linde. (P.) ....... 790
Detroit Copper Mining Co. of Arizona ....... 288
Deutsche Bunsen Gesellschaft. Leipzig Convention ....... 495
De Wolf, Philip ....... 799
Diesel engine ....... 347
Diesel engine. Large ....... 663
Digest of Electrochemical U. S. Patents....69, 142, 210, 277, 425, 485, 543, 609, 667, 736, 799
Distillation. Hardwood, at Pacific Coast. Palmer ....... 623
Distilling. Water. Link ....... 796
D'Olier Centrifugal Pump & Machine Co. 203
Dome mill, Porcupine. Forbes. (S.) ....... 349
Dorr, J. V. N. ....... 541
Dorr classifiers. Leaching copper ores at Butte and Duluth. (S.) ....... 481
Dry chloridization of ores. Malm....128, 780
Dryer. Continuous dustless for sludge material. Mackliad ....... 272
Dryer. Ruggles-Coles ....... 360
Dudley, W. L. Obituary ....... 746
Dunn pulverized coal burner. Roush. 19, 94
Dunn, Gano ....... 485
Duquesne Light Co. ....... 702
Duquesne revolution ....... 47
Duriron castings. Chemical ....... 274
Dwight, Arthur S. ....... 485
Dwight-Lloyd and Huntington-Heberlein processes. Dwight. (S.) ....... 782
Dye fixing. Electrolytic. (D.) ....... 610
Dyes. Coal tar in America. Stone ....... 679
Dyestuff and chemical industry ....... 684
Dyestuff industry and the war. Matheson, Hesse, Matos ....... 552
Dwight-Lloyd sintering process. Laws. (P.) ....... 532

## E

EAKINS, L. G. ....... 667
Eames, Luther B. ....... 69
Earths. Rare. Electrolytic separation. Dennis ....... 791
Eastern Tanners Glue Co. ....... 304
Eastman, H. M. ....... 735
Economic aspects of industrial chemistry. Hesse ....... 584
Education. Engineering ....... 214, 281
Efficiency exposition ....... 106
Eilers, Karl E. ....... 485
Electric Furnace Co. of America ....... 485
Electric testing manual ....... 30[illegible]
Electrification, Railroad, as a relief of economic stresses. Johnson ....... 614
Electroanalysis. See Analysis.
Electrochemical plants. Evaporator problem. Mantius ....... 715, 722
Electrochemicals. Census in U. S. ....... 770
Electrochemistry. Economic and æsthetic aspects. Roeber ....... 344
Electrochemistry. Possibilities of St. Louis as a field for. Carrier ....... 289
Electrodes. Carbon. Skin effect. Hinckley ....... 223
Electrode construction. Brown. (P.) ....... 728
Electrode construction for furnaces. Richards. (P.) ....... 533
Electrode. Copper. Reproducibility Getman ....... 706
Electrodes. Protective coating. Fleming. (P.) ....... 533
Electrolysis with alternating current. Richards and Roepper. (D.) ....... 668
Electrolytic flames. Bancroft ....... 334
Electrolytic Gas Co. ....... 360
Electrolytic Products Co. ....... 67
Electrometric titration. Ziegel ....... 705
Electrostatic precipitation of fumes. Cottrell process. Howard. (S.) ....... 783
——Dunn. (S.) ....... 784
Electrostatic process for detarring gas Steere ....... 775
Electrostatic separation. Wentwood. (S.) 782
Elements. High-frequency spectra and structure of matter ....... 363
Elements. Undeveloped ....... 79, 181
Elliott, Arthur H. ....... 485
Elliott, H. A. ....... 206
Elmore sampler ....... 799
El Ore Mining & Milling Co ....... 208
Elutriation. Grading analyses. Stadler. (S.) ....... 536
Emanuel, Louis ....... 141
Emerson, F. H. ....... 609
Emissivity of metals and oxides. Burgess and Foote ....... 525
Energy balance of blast furnace. Cornell ....... 747
Energy, determination of free. Beutner. 342
Energy, Electrical. Characteristics as affecting chemical industries. Steinmetz ....... 329
Energy of vaporization of carbon. Hering ....... 526
Energy, True chemical, of combination. Brophy ....... 674
Engineer, Metallurgical, in steel works Hall ....... 303
Engelhard, Charles ....... 356
Engineering education ....... **214**
Engineering standard specifications. British ....... 652
En Holm, O. A. ....... 141
Erbium by electrolysis. Dennis. (P.) ....... 791
Etching. Electrolytic. (D.) ....... 543
Ethics. Professional. Raymond ....... 428
European war ....... **545**
Evans, James Porter. Obituary ....... 667
Evaporator problems in electrochemical plants. Mantius ....... 715, 722
Explosions. Bitumen and electric mains. 80
Explosions. Electric mains ....... 597
Explosion. Wheeling Creek Mine ....... 389
Explosives. Recent developments. Le Sueur ....... 55
Exports and imports (British) ....... 34
Eye, C. M. ....... 609

## F

FARADAY Society ....... 253
Farrant, J. C. ....... 799
Feed-water compound. Boiler. Bailey ....... 475
Feed-water difficulties ....... 419
Feld, Walter ....... 426, 514
Feldkamp, F. A. ....... 67
Ferguson, C. C. ....... 69
Ferro-alloys. Low-carbon. Bleecker. (P.) ....... 413
Ferromanganese. Electrically melted ....... 295
Fertilizers. Nitrogen. Baekeland ....... 559
——See also Calcium cyanide and Nitrogen, atmospheric fixation.
Filter for slimes. Alinder. (P.) ....... 195
Filter for slimes. Butters. (P.) ....... 530
Filter. Leaf. Butters. (P.) ....... 65
Filter leafs. Cleaning with lactic acid. Leach. (P.) ....... 530
Filter leaf. Shepherd. (P.) ....... 479
Filter medium. Filtros ....... 537
Filter press. Berrigan, in Cuban sugar plant ....... 482
Filter press. Burger ....... 61, 101
Filter press, Clamshell. Sweetland ....... 57
Filter press. Design. Motherwell ....... 284
Filter press, Kelly, in Cuban sugar works. 539
Filter press. Laboratory. Worthington. 540
Filter. Slime. Drage. (P.) ....... 260
Filter. Slime. Ridgway. (P.) ....... 659
Filter. Slime. Trent. (P.) ....... 658
Filtration. Continuous water. Hyatt ....... 131
Filtros ....... 537
Fink furnace, Present status. Pulsifer ....... 731
Fire alarm. Silver sulphide. Fitz Gerald. 341
Firebrick. Johnson ....... 672, 740
——Reed ....... 672, 740
Fires. Extinguishing, in volatile liquids. Barrier ....... 105
Fitz Gerald Laboratories ....... 353
Flames. Electrolytic. Bancroft ....... 334
Flash and fire tests for lubricating oils Siever ....... 188
Flint pebbles in California ....... 72
FLOTATION.
——Antimonial silver ore. Campbell. (P.) ....... 198
——Cyaniding ....... 221
——Dry concentration and flotation at Joplin ....... 492
——Litigation decision ....... 362, 366
——Oil at Butte and Superior ....... 22[illegible]
——Selective. Horwood process. (S.) 350, 414
——Lead and copper ores. ....... 77
——Minerals Separation Co. ....... 77
——Nodulizing. Flotation concentrates. Payne. (S.) ....... 78[illegible]
Flow indicator. Light ....... 171
Flue dust. Agglomeration for smelting Cooper. (P.) ....... 6[illegible]8
——Filtration from furnace gases. Rigg (P.) ....... 53[illegible]
——Handling. (S.) ....... 48[illegible]
——Nodulizing. Addicks. (S.) ....... 654
Forbes, D. L. H. ....... 667
Ford-Parks system of bucket filling ....... 12[illegible]
Forge furnace. Rockwell. ....... 354
[illegible] ....... 24[illegible]
Fra[illegible], L[illegible] ....... 426
Fre[illegible], R. J. ....... [illegible]
Freder[illegible]. Electr[illegible] [illegible] ....... 576
Frothy [illegible] for [illegible] ....... [illegible]
Fuel. Heavy Mexica[illegible] [illegible] ....... [illegible]
Fuel oil ....... [illegible]4, 74[illegible]
Fuel. Pulverized coal. [illegible] ....... [illegible]
Fuller-Lehigh pulverizer [illegible] ....... 66[illegible]
FUME.
——Electrostatic precipitation. [illegible] process. Howard. (S.) ....... 78[illegible]
——Dunn. (S.) ....... 784
——Me[illegible] [illegible] (P.) ....... 19[illegible]
——Re[illegible] [illegible] Strong ....... 604
——Recovery. Progress ....... 670
——Removal of sulphur. Hall process ....... 718
——Smelter fume damage in Salt Lake Valley ....... 61[illegible]
Electroplating. Bad[illegible] [illegible] Miller ....... 714
Electro-metallurgy of iron and steel. Johnson ....... 16[illegible]
Electric steel melting ....... [illegible]
——Sulphurous acid. From Smelters. Wagner ....... 17[illegible]
——Sulphurous, at Mammoth smelter. Martin ....... 769
Electric Melting and Smelting. See also Furnace, Electr[illegible]
FURNACE, BLAST.
——Blowers. McQuigg ....... 28[illegible]
——Johnson ....... [illegible], 311
——Boiler plant. Johnson ....... 17[illegible]
——Gas, its cleaning and utilization. Johnson ....... 6[illegible], 76[illegible]
——Handling the raw materials. Johnson ....... 44, 117
——Stack. Johnson ....... 451, 49[illegible]
——Stoves. Johnson ....... 395
——See also the different metals.
Furnace. Channel, for burning ore briquets. Kamen. (P.) ....... 35[illegible]
Furnace. Combination smelting and converting. Knudsen (P.) ....... 64
FURNACE, ELECTRIC:
——GENERAL:
——Economies of operation. Fitz Gerald ....... 33
——Electrodes. Carbon. Hinckley ....... 717
——Electrode construction. Brown. (P.) ....... 7[illegible]
——Electrode construction. Richards. (P.) ....... 53[illegible]
——Electrodes. Protective coating. Fleming. (P.) ....... 53[illegible]
——History. Johnson and Sieger. ....... 4[illegible]
——Keeping the furnace hot during periods of idleness. Schmelz ....... 21[illegible]
——Power for work. Horry ....... 33[illegible]
——Regulators. Turnbull ....... 333, 42[illegible]
——VARIOUS DESIGNS:
——Arc. Development of steel casting industry. Rennerfelt ....... [illegible]
——Cascade attachment for graphite furnace. Northrup ....... 3[illegible]
——Combined arc and resistance. Guthrie and Karch. (P.) ....... 53[illegible]
——Electrode arrangement. Rennerfelt. (P.) ....... 53[illegible]
——Granannular. Jeffries ....... 154
——Induction furnace. Efficiency and refining. Bjorkstedt ....... 14[illegible]
——Induction furnace. Efficiency and refining. Vom Baur. ....... 21[illegible]
——Induction furnace for steel melting and refining. Rennerfelt ....... [illegible]
——Induction furnace. Efficiency and refining. Harden. ....... 21[illegible]
——Induction. Helfenstein. (P.) ....... 72[illegible]
——Medium—temperature. Schmelz. ....... 64[illegible]
——Medium temperature. Stassano and Petinot. (P.) ....... [illegible]
——Moving. Electrode. Buckman (P.) ....... [illegible]
——New high-temperature. Northrup ....... 3[illegible]
——Small-size arc for melting and refining. Rennerfelt ....... 2[illegible]
——MANUFACTURE OF:
——Abrasives. Allen. (P.) ....... 53[illegible]
——Brass and German silver ware annealing ....... 48[illegible]
——Brass. Central station view point. St. John ....... 64[illegible]
——Brass. Dorsey ....... 644
——Brass. Gillett and Lohr. ....... 64[illegible]
——Brass. Hering furnace. Clamer and Hering ....... 64[illegible]
——Brass. Schmelz ....... 64[illegible]
——Calcium cyanamide. Landis. (P.) ....... 53[illegible]
——Carbon, granular, calcination and graphite production. Brown (P.) ....... 72[illegible]
——Copper. Melting cathode copper. Lyon and Keeney. (S.) ....... 7[illegible]
——Ferromanganese. Electrically melted ....... 29[illegible]
——Iron and steel. Johnson ....... 16[illegible]
——Iron smelting. Electric at Hardangen. Harden ....... 82, 223, 444
——Iron and steel. Electric steel in England ....... 94
——Iron and steel. Frick ....... 6[illegible]
——Steel castings. Hansen ....... 33[illegible]
——Steel. Clark ....... 336

Furnace, Electric: (Continued.)
—— Steel. Heroult ........ 326
—— Steel castings direct from ore... 326
—— Steel direct from ore. Humbert and Hethey ........ 651
—— Steel. French army and navy... 605
—— Steel. Versus Tropenas converters for steel castings. Muntz 379
—— Steel. Walker. (P.)........ 528
—— Tin. Harden ........ 94
—— Tin. Wile ........ 717
—— Zinc. Johnson ........360, 494
—— Zinc. Specketer. (P.)........ 531
—— Zinc. Thierry ........ 789
Furnace. Fink. Present status. Pulsifer ........ 731
Furnace. Forge. Rockwell........ 354
Furnace. Heating. Rockwell. (P.).... 64
Furnace. Melting. Mellen. (P.)...... 727
Furnace. Metallizing. Iron sponge. Mathewson and Laist. (P.).... 413
Furnace. Metallurgical. Mixing ores for furnace charges. Indeterminate cases. Chauvenet ........ 626
Furnace. Open-hearth. Lining. Eldred. (P.) ........ 413
Furnaces. Physical versus chemical actions. Hering ........ 439
Furnace. Pressure air-cooled roaster. Herreshoff ........ 199
Furnace. Roasting. Air-cooled rabble arm. Wedge. (P.) ........ 532
Furnace. Roasting. Air cooling. Fowler. (P.) ........ 532
Furnace. Roasting. Heat conservation. Wedge. (P.) ........ 413
Furnace. Smelting. Vaporization of jacket water ........ 420

G

Gahl, Rudolf ........ 209
Garred, U. A........ 209
Garrey, Geo. H........ 426
Gas:
——Accelerator for gasoline gas plants. Kimber ........ 740
——Analysis ........ 677
——Analysis of natural gas. Brown.... 168
——Calorimeter. Recording........ 662
——Coal gas plant at Cyanamide plant.. 265
——Coal gas residuals. Wagner........ 696
——Compressor. Nash ........ 423
——Cyanide production. Tutwiler. (S.). 785
——Detarring. Steere ........677, 778
——Engines for blowers........ 319
——from blast furnaces, its cleaning and utilization. Johnson ........ 685
——manufacture. Rittman ........ 678
——Producers ........ 440
——Producers in glass factories........ 207
——Producer. Cold cleaned for high-temperature regenerative furnaces 601
——Producer, from wood waste. Lygo.. 33
——Producer. Hopper. (P.)........ 727
——Producer, in glass factories........ 207
——Valve. High-pressure ........ 794
Gasoline gas plants. Accelerators for. Barton ........ 419
Gasoline gas plants. Kimber........ 740
Gasoline. Patent processes for making casing head gasoline. Chute........ 147
Geevor Mill. Cornwall. (S.)........ 262
Geissinger Regulator Co........ 661
Gemmell, R. C........ 542
General Chemical Co........ 200
Geenral Electric Co........ 475
General Electric Review........ 730
General Filtration Co........ 537
Generators. Prime movers of elctrolytic. Longwell ........ 92
Geological Survey....41, 188, 198, 253, 360, 419, 424, 440, 539, 543, 623, 635, 661
Geology and mining. Hatch........ 325
German silver. Metallography. Thompson ........ 785
Gesellschaft Deutscher Metallhütten und Bergleute. Goslar convention.. 583
Gibbs medal to Ira Remsen........ 381
Gillard, Warren R........ 735
Glass factories. Application of producer gas. ........ 207
Glazed refractory articles. Malm. (P.).. 140
Glucose. Legislation ........ 16
Gold and Silver:
——Aluminium. Precipitation from cyanide solutions. Butters. (S.).. 351
——Amalgamating in cyanide solutions. Randall ........ 248
——Assaying for gold and platinum. (S.). 480
——Brown cyanide patent decision..219, 286
——Calorimetric estimation of gold in cyanide solutions ........ 460
——Chaffer's Mill. Kalgoorlie (S.).... 783
——Chloridizing at Silver City, Utah... 757
——Chlorination at Park City ....431, 492
——Chlorination. Christensen and Holt. (P.) ........ 658
——Chlorination in Utah........ 222
——Cleaning filter leaves with lactic acid. Leach. (P.) ........ 530
——Concentration of complex sulphide ores from Mary Murphy mine. 21, 157, 217, 243
——Concentration old tailings. Silver Lake ........ 11
Gold and Silver: (Continued.)
——Continuous slime thickening apparatus. Rothwell. (P.)........ 479
——Custom cyanide mills........ 72
——Cyanidation of silver sulphide ores. Linton. (S.)........ 349
——Cyanide consumption in U. S. and Canada ........ 743
——Cyanide practice in Porcupine district ........567, 636, 634
——Cyanide practice in Porcupine District. Spicer ........ 742
——Cyanide process. Review. Mulholland. (S.) ........ 263
——Descriptive technology of gold and silver metallurgy. Allen. (S.). 653
——Detection of platinum in gold-silver cupellation beads. (S.)........ 137
——Determining free gold in quartz..... 744
——Dome mill, Porcupine. Forbes. (S.). 349
——Filtering slimes. Butters. (P.).... 530
——Filter leaf. Butters. (P.)........ 65
——Filter leaf. Shepherd. (P.)........ 479
——Fine grinding on the Rand. (S.).. 414
——Flotation and cyaniding........ 221
——Flotation antimonial silver ore. Campbell. (P.) ........ 198
——Gold-bearing scheelite in New Zealand. Gudgeon. (S.)........ 53
——Gold dredging ........ 78
——Gold milling in Georgia........ 10
——Granulated zinc precipitation from cyanide solutions. Urquhart. (P.) ........ 351
——Grinding ore for cyanidation........ 611
——Grinding ore for cyanidation. Tentland ........ 621
——Motherlode. Sheep Creek Mill..... 492
——Nipissing Mill. Clevenger. (S.).... 653
——Nipissing practice. Johnston....189, 348
——Oil flotation at Butte and Superior. 222
——Ore treatment at Cobalt. Parmelee. 467, 507
——Parting silver and gold. Moebius. (D.) ........ 69
——Precipitation from cyanide. Ross. (P.) 530
——Preparation of refractory ore for cyaniding. Butters. (P.)...... 658
——Progress in metallurgy in 1913...... 3
——Rapid cyanidation. Reinohl........ 734
——Refining gold. Wohlwill. (D.)..70, 142
——Refining of precious metals. Lacroix ........ 441
——Roasting precious metal residue from electrolytic copper. Wales. (P.) ........ 412
——Rochester Mines Co........ 677
——Land leaching at Oroya Black Range. (S.) ........ 414
——Silver-Cobalt ores. Dyckerhoff. (P.). 412
——Silver. Resistivity. Solid and molten. Northrup (S.) ........ 535
——Slime agitator. Marcy (P.)........ 195
——Slime filter. Alinder. (P.)........ 195
——Slime filter. Drage. (P.)........ 260
——Slime filter. Ridgway. (P.)........ 659
——Slime filter. Trent. (P.)........ 658
——Smelting furnace for cyanide precipitate ........ 492
——Stamp mills and milling........ 225
——Transvaal gold production......194, 271, 475, 542, 649
——Treatment of anode residue. Keller. (P.) ........ 728
——Tube milling in all-slime cyanide practice. Tentland ........ 750
——Volatilization of metals as chlorides. Howe. ........71, 137, 414
——See also Complex Ore Problems.
Goldfield Consolidated Mines Company.269, 287
Goldschmidt, Hans ........485, 495
Gould, Free and Ash........ 735
Govett, F. A........ 609
Grading analyses by elutriation. Stadler. (S.) ........ 536
Grananular electric furnace. Jeffries... 154
Granby Company ........ 676
Great Britain. Notes on chemistry and metallurgy....33, 130, 179, 263, 325, 415, 597, 650, 724
Grier, T. J. Obituary........ 734
Grinding ore for cyanidation........ 611
Grinding ore for cyanidation. A suggested modification for all sliming practice ........621, 672
Grönwall furnace ........ 209
Grunbach & Sohn, Ernst........ 66
Guess, H. A........ 209
Guiterman, Franklin ........277, 667
Gun-Crete Co. ........ 411
Gun metal. Effect of temperature .... 597
Gyroscopic compass. Scott and Rozie .. 786

H

Haas, Herbert ........ 69
Haldane, W. G........ 542
Hall process of desulphurization........ 718
Hamilton, F. H........ 609
Hamilton, J. W. H........ 735
Hammer-bar pulverizer ........ 358
Hanovia Chemical & Mfg. Co........ 356
Hardening metals. Edwards and Carpenter ........ 651
Hardinge, H. W.........209, 347, 485, 542
Hardness of metals. Brinell method.. 205
Hardness of ores in tube milling. Blyth (S.) ........ 537
Hardwood. Possibilities of distillation on the Pacific Coast. Palmer..... 623
Hasslacher, Jacob ........ 609
Hawkins, E. N........ 210
Heat balance of blast furnace. Cornell.. 747
Heating furnace. Rockwell. (P.)...... 64
Heating leaching solutions. Laist. (P.).. 788
Heating mill buildings........ 676
Heat treatment of steel castings. Tease, Young and Strand........ 193
Heat treatment of steel. Mainwaring... 365
Heinze, F. A. Obituary........ 746
Heroult. Obituary ........361, 382
Herreshoff roaster. New........ 199
Heyn, E. ........ 347
Hills, Victor G........ 210
Hoisting at blast furnaces........ 121
Hoisting machinery. Johnson........ 44
Hoover, H. C........309, 609, 799
Hoover and Mason bin........ 119
Hoover and Mason unloader........ 49
Hornbostel, Henry F........ 485
Hoskin, A. J........ 799
Hulbert, W. R........ 426
Hulett unloader ........ 49
Humbert, E. P........ 141
Huntington, Heberlein and Dwight, Lloyd processes. (S.)........ 782
Hyatt, John W. Portrait and presentation of Perkin medal........ 131
Hyde, A. L........ 496
Hyde, J. M........ 277
Hydrogen electrolytic. Garnti and Pompili. (D.) ........ 800
Hydrogen. Electrolytic. (D.)........ 544
Hydrogen. Electrolytic. Huber. (D.).. 610
Hydrometallurgy: Joys of its theory, woes of its practice. Bleecker.. 8
——Malm ........ 75
——Skinner ........ 8
Hydroturbine. Nash ........ 423

I

Idaho. Metallurgy in........ 737
Imports and exports (British)........ 34
Improved Equipment Co........ 266
Induction furnace. See Furnace. Electric.
Industrial peace ........ 279
Industrial Research, Inc........ 354
Industrial works locomotive cranes...... 798
Industries, chemical. See Chemical and Chemistry.
Ingersoll-Rand Co. ........ 268
Inland Steel Co........ 306
Institute of Metals (British)........534, 724
Institution (British) of Electrical Engineers ........ 33
Institution (British) of Mining and Metallurgy ........179, 325
Institution of Mining Engineers (British) 650
Institution of Petroleum Technologists... 130
Insulation of commutators. Bakelite..... 603
Instruments. Long-distance transmitting, indicating and recording system. 797
Intelligence, craft and cunning........ 429
International Congress of Applied Chemistry. Ninth........ 435
International Electrical Congress........ 36
International Engineering Congress..... 11, 271, 366, 746
International Harvester Co........ 436
International Oxygen Co........360, 794
International Smelting & Refining Co.... 165
Inventory, Metal. In an electrolytic copper refinery. Deacon........ 338
Iodine. Number of linseed and petroleum oils ........ 596
Iron and Steel:
——Agglomerating flue dust for smelting. Cooper. (P.) ........ 658
——Alloys. Hadfield ........ 598
——American ingot iron in England.... 424
——Annealing of malleable castings. Storey ........ 383
——Anticorrosive coating by electrolysis. Hollis. (D.) ........ 736
——Bessemer converter. Bretand. (P.) 529
——Blast furnace blowers. McQuigg.... 286
——Blast furnace boiler plant. Johnson.. 171
——Blast furnace gas. Cleaning and utilization. Johnson........685, 760
——Blast furnace. Heat balance........ 747
——Blast furnace stack construction. Johnson ........451, 497
——Blast furnace stack. Shannon. (P.) 351
——Blast furnace stoves. Johnson...... 305
——Blowing apparatus for blast furnaces. Johnson ........230, 311
——Briquetting fine ore. Mathesius. (P.) 657
——Briquetting iron ores. Crusius. (P.) 788
——Cooling open-hearth furnace posts. Parks. (P.) ........ 788
——Corrosion ........ 179
——Corrosion. Effect of Pickling. Richardson ........ 759
——Corrosion prevented by contact with zinc. (D.) ........ 278
——Determination of carbon in. Brown. 390
——Determination of manganese. Analoid method ........ 793
——Determination of chromium in steel and iron. Walters........ 310
——Determination of silica and alumina in iron ores. Wurzel ........ 430
——Duriron castings for chemical purposes 274

Iron and Steel: (Continued.)
—Electric arc furnace in steel casting industry 581
—Electric crane for handling long iron rods 482
—Electric furnace for steel making. Clark 336
—Electric iron smelting at Hardanger. Harden 82, 223, 444
—Electric steel castings. Hansen and Clark 335
—Electric steel for French army and navy 605
—Electric steel in England 94
—Electric steel. Walker. (P.) 528
—Electrodeposition of iron. Effect of addition agents. Li and Watts 343
—Electrolytic iron. Boucher. (P.) 528
—Electrolytic iron. Guillet 787
—Electrolytic iron. Storey 342
—Electro-metallurgy. Johnson 165
—Electrostatic separation of zinc and iron at Midvale. (S.) 782
—Handling raw materials at blast furnace. Johnson 44, 117
—Hardening. Edwards and Carpenter. 651
—Heat treatment of steel castings. Pease, Young and Strand 193
—Heat treatment of steel. Mainwaring. 365
—High-pressure furnace. Otto. (P.) 728
—Induction furnace. Efficiency and refining. Vom Baur 217
—Induction furnace for steel melting and refining. Rennerfelt 74
—Iron industry in 1913 6
—Iron-nickel-copper alloy. Clamer. (P.) 413
—Iron ore output, 1913 635
—Iron sponge. Mathewson and Laist. (P.) 413
—Iron sponge by reduction without smelting. Alford. (P.) 529
—Magnet steels 33
—Magnetized roasted zinc and iron ores. Brooks. (P.) 352
—Manganese steel. Hadfield and Hopkinson 651
—Market reports 12, 78, 148, 259, 288, 367, 433, 493, 554, 618, 675, 742
—Mesabi ores. Concentration tests 152
—Metallurgical engineer in steel works. Hall 303
—New method for determining temperature of ingots. Homan 364
—Nodulizing kiln (Ross) 65
—Open-hearth furnace roof. Water-cooled. (P.) 529
—Ore reduction. Junguera. (P.) 657
—Output in 1913 361
—Oxygen in cast iron. Johnson 192
—Paving brick from blast furnace slag. 43
—Phosphorus in steel. Roxenhain 650
—Pig iron production statistics 143
—Progress of electric furnace 179
—Rails. Finishing temperatures and properties. (S.) 594
—Rail steel. Changing character 215
—Rail steels for electric railways 263
—Raw fuel in blast furnaces. Prudhomme. (P.) 351
—Raw material for steel production 487
—Reduction by gases below red heat. McLarty. (P.) 65
—Reduction of iron by gases. Bourcourt. (P.) 529
—Refining pig iron. Stobie. (P.) 728
—Refining steel. Hethey. (P.) 529
—Scraps and finished steel production 547
—Sintering iron-bearing materials. Klugh. (P.) 197
—Sponge iron. Use of peat. Odelstierna. (P.) 728
—Steel castings direct from ore 326
—Steel Corporation. Dissolution suit 671
—Steel Corporation report 214
—Steel costs and selling prices 72
—Steel direct from ore. Humbert and Hethey 651
—Steel trade's prospects 739
—Tilting open-hearth furnace. Schuster. (S.) 535
—Titanium. Incorporating. Rossi. (P.) 657
—Titanium nitride in steel. Comstock 577
—Tropenas converters vs. electric furnaces for the manufacture of. Muntz 379
—Utilizing blast-furnace flue dust. Baggaley. (P.) 139
—Vismera pure iron 306
—Wage problem 281
—Welding powder. Eisengraber. (P.) 351
—Welfare work in the steel industry 428
Iron and Steel Institute (British) 43, 368, 436, 494, 534, 650
Iron and steel market 12, 78, 148, 259, 288, 367, 433, 493, 554, 618, 675
Isbell concentrator 601

J

Jacket water. Vaporization. Nesmith 420
Jackling, D. C. 542, 609
Jacoby, H. E. 347, 426
Jahn, Wm. F. 209
Jeffrey, J. W. 542
Jennings, S. J. 69
Jigging. Dry. Unsized ore 555
Johns-Manville Co., H. W. 357, 770
Johnson Electric Smelting, Inc 360, 494
Johnson, E. M. 277
Johnson, J. E., Jr. 735

K

Kaeding, C. D. 542
Kaufman, F. A. 542
Keeney, R. M., and Lyon, D. A. 209
Keeney, R. M. 347
Kelley, David J. Obituary 746
Kelly Filter Press Co. 539
Kemp, Lorin 609
Kennedy, E. T. 667
Kerr, Guy M. 542
Keuffel & Esser Co. 423
Keystone Electrical Instrument Co. 208
Kick's law of crushing 783
Kick's law of crushing. Speak. (S.) 481
Kieselguhr Co. of America 309
Kieselguhr industry. Boeck 109
Kiln. Dry for timber products 538
Kiln. Nodulizing for iron ores. Ross. (P.) 65
Kimber, H. P. Accelerator for gasoline gas plants 740
Klepinger, J. H. 210
Knight, A. S. 347
Knight-Christensen Metallurgical Co. 376, 759
Koerner, Th. 66
Kolbeck, F. 485, 738
Kunhardt, Wheaton B. 485

L

Laboratory apparatus and reagents catalog. Thomas 780
Laboratory mill. Grunbach 66, 200
Laboratory. Ore testing. Charles Butters 268
Laboratory. Vacuum cleaning 68
Lactic acid for cleaning filter leaves. Leach. (P.) 530
Lakeman, C. B. 667
Large electric steel furnace installation 62
La Rose Consolidated Mines Co. 432
Lass, W. P. 667
Laundry. Electrolytic cleaning. (D.) 609
Lavoisite system of generating oxygen 417
Leaching. See the different metals on hydrometallurgy.
Lead:
—Atomic weight 487
—Atomic weight. Fajans and Honigschmid 495
—Bag house. Anderson. (S.) 654
—Blast furnace. Bosh. Anderson. (S.) 782
—Concentration of complex sulphide ores from Mary Murphy mine. Collins 21, 157, 217, 243
—Determination at Broken Hill. (S.) 54
—Electrodeposition. Mathers 714
—Feathery for accumulator plates. Clark. (D.) 668
—Filtration of flue dust from furnace gases. Rigg. (P.) 531
—Flotation of lead and copper ores 77
—Flotation. Selective. Horwood process. (S.) 350, 414
—Isherwood process for refractory zinc lead ores. (P.) 351
—Kansas and Arkansas 419
—Leaching sulphide ores with nitric acid. Kingsley and Rankin 583
—Lead peroxide by electrolysis. Luckow. (D.) 709
—Matte converting at Tooele. Kuchs. (S.) 654
—Pigment furnace. Holley. (P.) 788
—Plating. Mathers 714
—Production 543
—Refining and desilverizing lead bullion. Thum. (P.) 659
—Refining. Betts. (D.) 210, 211
—Refining. Recovery of zinc and antimony. Divine. (S.) 781
—Smelting in blast furnace. Palmer. (S.) 651
—White lead manufacture. Stewart. (P.) 41[illegible]
—White lead. Owens 342
—See also complex ore problem.
Leadville 106, 149
Legislation. Effect on chemical industries. Wagner 15
Legislation. Federal mining and metallurgical 280
Lehman, J. George 209
Leighton, Alan 735
Lehigh Car Wheel & Axle Works 663
Leiman Brothers 68
Leonard, William D. 277, 542
Lewis, D. L., Jr. 609
Lexington Instrument Works 662
Lidbury, F. A. Portrait 377
Lifting solutions in quantity by compressed air. Phelps 301
Light from unconsumed electrodes. Vosmaer 377
Lighting. Chemistry in 684
Lime plant at cyanamide works. 265
L[illegible]g [illegible] proof [illegible] for [illegible] 7[illegible]
Lining. Magnetite, of basic copper converters. Wheeler and Krejci [illegible]
Lining. Master [illegible] tanks [illegible]
Lining open-hearth [illegible] (P.) 4[illegible]
Link Belt Co. [illegible]
Link Manufacturing Co. [illegible]
Little, Arthur D., Inc. 4[illegible]
Livingston, Goodhue 4[illegible]
Locomotive cranes [illegible]
Loeb, Morris. Presentation of bronze bust to Chemists' Club [illegible]
Lubricating oil. Flash and fire test. Siever [illegible]
Lyon, D. A., and Keeney, R. M. [illegible]
Lyon, Frederick [illegible]
Lyons Atlas Co. 6[illegible]

M

McAllister, A. S. [illegible]
McCaffery, R. S. [illegible]
McKee, A. G. [illegible]
McKee-Baker bin [illegible]
Macadamum [illegible]
MacDonald, Bernard 141, [illegible]
MacGregor, H. P. [illegible]
Magnesite. Effect of steam. Youngman [illegible]
Magnesite in California [illegible]
Magnet steels [illegible]
Magnetic iron oxide coating. Winslow (D.) [illegible]
—Hollis. (D.) [illegible]
Magnetic separator. Ulrich. (S.) [illegible]
Magnetite linings for basic copper converters. Wheeler and Krejci (S.) [illegible]
Mainwaring, W. D. [illegible]
Malayan Tin and Rubber Journal [illegible]
Malleable castings. Annealing. Storey [illegible]
Malm, John L. [illegible]
Mammoth smelter. Fumes treatment. Martin 769
Mangan, W. B. [illegible]
Manganese bronze. Corse [illegible]
Manganese bronze. Skillman [illegible]
Manganese ore in California [illegible]
Manganese. Determination in iron, steel, ore. Analoid method. [illegible]
Manganese from ores. Hensler. (P.) 66
Manganese steel. Hadfield and Hopkinson [illegible]
Market. Iron and steel 12, 78, 148, 259, 288, 367, 433, 4[illegible]3, 554, 618, 675, [illegible]
Market. Non-ferrous 13, 78, 2[illegible]9, 259, 434, 496, 616, [illegible]75, 74[illegible]
Market prices (London) 34, 130, 180, 264, 326, 416, 534, 600, 652, [illegible]
Marshall, L. M. [illegible]77, [illegible]
Martin, Douglas S. Obituary [illegible]
Massachusetts Institute of Technology [illegible]
Meade, R. K. 6[illegible], [illegible]
Meissner, Carl A. [illegible]
Mellen Co., Thomas [illegible]
Melting furnace. Mellen. (P.) [illegible]
Melting points of copper alloys [illegible]
Mendenhall, J. B. [illegible]
Mercury in California [illegible]
Mercury in Nevada [illegible]
Mercury cathode. Electrolysis of chloride solutions. Le Sueur [illegible]
Messina (Transvaal) Development Co. [illegible]
Messler, E. L. [illegible]
Mesta Machine Co. 171, [illegible]
Metallurgical engineer in steel works [illegible]
Metal production in 1913 [illegible]
Metallurgical engineer in the steel works. Hall [illegible]
Metals Coating Co. of America [illegible]
Metals. Secondary. Recovery from waste and scrap [illegible]
Mexico. Situation 4[illegible], [illegible]
Miami Copper Co. [illegible]
Michigan Alkali Co. 684
Michigan. Labor situation [illegible]
Microstructure of electrolytic iron. Storey [illegible]
Microstructure of raw and manufactured copper. Mothewell [illegible]
Miller, Rudolph P. [illegible]
Mill. Laboratory. Grunbach [illegible]
Mill. Laboratory and sample. Abbe [illegible]
Mill, Tube. See Tube Mill.
Milling and stamp mill notes. Storms. [illegible]
Minerals separation 362, [illegible]
Mine rescue. Nevada State, rescue and first aid meet. Lincoln [illegible]
Minerals Separation Co. [illegible]
Mining and metallurgy. Story of. Rickard [illegible]
Mining and Scientific Press [illegible]
Mining Magazine [illegible]
Montezuma Copper Co. [illegible]
Moffat Irving Steel Works [illegible]
Moldenke, R. [illegible]
Monel metal 68, [illegible]
Montana [illegible]
Montana. Metallurgy in [illegible]
Moore, P. W. Ductile tungsten [illegible]
Morgan Engineering Co. [illegible]
Mount Morgan Gold Mining Co. [illegible]
Mountain Copper Co. [illegible]
Muir, L. M. [illegible]
Munning-Loeb Co. [illegible]
Muntz metal. Stead and Stedman. (S.) [illegible]

## N

NAPHTHALENE from coal gas. Wagner ... 698
Nash Engineering Co....423, 795
Nathan, Albert F. ... 735
National Malleable Castings Co ... 326
National Physical Laboratory....599, 649
Nevada. Smelting ... 77
Nevada Consolidated Copper Co..432, 460, 745
Nevada. State mine and rescue first aid meet. Lincoln ... 615
Newberry, Andrew W. ... 667
New York City. Sanitation control. Lederle ... 55
Niagara Falls. Aesop at....71, 214
NICKEL:
—Alloy with tungsten. Kreusler. (P.) 728
—Analysis. Marsh ... 709
—Copper-nickel ore treatment. Borchers and Pedersen. (P.) ... 659
—Electrodeposition. Bennett, Kenny and Duggliss ... 340
—Electrodeposition. Duggliss and Bennett ... 340
—Electrolytic process. Frasch. (D.) 142, 210, 211
—From silicate ores. Sulman and Picard. (P.) ... 412
—Iron-nickel-copper alloy. Clamer. (P.) ... 413
—In high-speed steels. Arnold and Reed 415
—Refining copper-nickel alloys. Browne. (D.) ... 211
—Refining nickeliferous copper. Ulke. (D.) ... 210
—Roasting copper-nickel matte. Kern and Merris. (P.) ... 198
—Separation of copper from nickel and cobalt. Hybinette. (P.) ... 531
—Welding with copper ... 619
Nipissing metallurgical practice. Johnston ....189, 348
Nissen stamps for tin ore. (S.) ... 198
Nitrates by electrolysis of peat. Dary.. 107
Nitric acid for leaching. Bueler ... 583
Nitride process. Bucher ... 725
NITROGEN. ATMOSPHERIC FIXATION:
—Baekeland ... 559
—Lowry ... 14
—Nitride process. Bucher. (P.) ... 725
—Rittman ... 476
—Absorption of nitrous vapors. Schloesing. (P.) ... 726
Nitrogen. Oxidizable variety. Lowry... 14
Nodulizing blast furnace flue dust. Addicks. (S.) ... 654
Nodulizing flotation concentrates. Payne. (S.) ... 782
Nodulizing kiln for iron ores. Ross. (P.) 65
Noise. Cost of ... 427
Non-ferrous metal market..13, 78, 209, 259, 434, 496, 616, 675, 745
Norris, Robert V. A. ... 485
North American Selling Co ... 360
Northrup, E. F. ... 340
Norway. Electric iron smelting at Hardanger in. Harden.....82, 223, 444
Norway. Electrochemical progress in 1913. Moltkehausen ... 124
Nungesser, Philip ... 735

## O

OBLIGATIONS. Professional. Of chemists. Whitaker ... 437
Oil. Electrolytic extraction from wool. Burton. (D.) ... 609
Oil flotation at Butte and Superior ... 222
Oil. Fuel. ....54, 491, 746
Oils. Linseed and petroleum. Iodine number ... 596
Oils. Lubricating. Flash and fire tests. Siever ... 188
Oil shale in skye ... 179
Oil tests ... 269
Old Dominion Copper Co ... 366
Oleomargarine. Legislation ... 18
Open-hearth furnace ports. Cooling. Parks. (P.) ... 788
Open-hearth furnace. Tilting. Schuster. (S.) ... 535
Open-hearth furnace. Water-cooled roof. Slick. (P.) ... 529
—See also Iron and Steel.
Ores. Mixing, for calculation of furnace charges. Chauvenet ... 626
Organizations. Central research. Choate. 285
Ormiston, H. O. ... 649
Orthophthalic acid. Solubility. Rivett and Rosenblum ... 14
Otto Coking Co., Inc. ... 253
Overvoltage. Richards ... 14
Oxy-acetylene welding and cutting..... 66
Oxygen and hydrogen. Electrolytic. Garuti and Pompili. (D.) ... 800
Oxygen. Electrolytic. (D.) ... 544
Oxygen. Electrolytic. Huber. (D.)... 610
Oxygen in cast iron. Johnson ... 192
Oxygen. Lavoisite system ... 417
Ozonator. Girard ... 40
Ozonator. Otto. ....37, 40
Ozonator Schneller ... 37
Ozonator Siemens ... 39
Ozonator Tesla ... 37
Ozonator. Vohr ... 40
Ozonator designs. Vosmaer ... 36
Ozone for ventilation. Hygiene. Czaplewski ... 254

## P

PACIFIC COAST. Possibilities of hardwood distillation. Palmer ... 623
Pacific Tank & Pipe Co ... 62
Packing house by-products. Wagner... 18
Paints. Waterproof ... 360
Panama-Pacific Exposition, San Francisco ... 436
Parasite. The technical ... 284
Parker, R. A. ... 210
Parmelee, H. C. ... 210
Parral tank system for leaching copper ores ... 141
Parsons, C. L. ... 277
Patents. Electrochemical. Digest..69, 142, 210, 277, 425, 485, 543, 609, 667, 736, 799
Patents. Recent chemical and metallurgical..63, 139, 194, 260, 351, 412, 479, 528, 657, 725
Patent suit decision. Brown cyanide..219, 286
Patent suit decision. Flotation......362, 366
Patent suit decision on chill-proof beer.. 80
Patent suit decision on pyrophoric alloys.. 218
Patterson Foundry & Machine Co ... 360
Paving brick from blast furnace slag.... 43
Pawling & Harnischfeger Co ... 436
Peat for sponge iron. (P.) ... 728
Peat. Nitrates by electrolysis of. Dury.. 107
Pender, Harold ... 542
Pentland, W. J ... 667
Perkins medal. Presentation to John W. Hyatt ... 131
Peters, Edward D ... 542
Petrol. Substitute for ... 180
Phelps, Dodge & Co ... 287
Phosphate deposits near Red Sea ... 619
Phosphoric acid from phosphate rock. Washburn. (P.) ... 533
Phosphoric acid. Haff. (P.) ... 65
Phosphorus. Determination of in phosphor bronze. Hagmaier ... 524
Phosphorus. Determination of in scheelite concentrates. Hagmaier ... 620
Phosphorus in bronze. Blow ... 465
Phosphorus in steel. Rosenhain.......650
Photography. Color of microstructure of ores. Rigg ... 30
Physical chemistry. Industrial applications. Rittman ... 475
Physical versus chemical actions in furnaces. Hering ... 439
Pickling chains. Anti-corrosive ... 206
Pickling. Effect upon corrosion of iron. Richardson ... 759
Pickling machines ... 171
Pierce, F. E ... 485
Pigment furnace. Lead. Holley. (P.).. 788
Pittsburgh Plate Glass Company ... 440
Pittsburgh. Soot fall ... 247
Piwonka, G. C ... 210
PLATING:
—Antimony. (D.) ... 278
—Badly conducting films. Miller.... 714
—Brass. Bennett and Davison ... 340
—Brass. Davison ... 340
—Bronze. (D.) ... 278
—Cadmium. Marble and Mathers.... 339
—Calorizing ... 730
—Capacity of electroplating plants..... 495
—Chromium. (D.) ... 544
—Cobalt. (D.) ... 278
—Copper. Walenn. (D.) ... 425
—Determination of free cyanide in solutions. Lundell ... 340
—Electroplating patents in chronological order. (D.)......277, 425, 485, 543, 609, 667, 736, 799
—Gold. Davis. (D.) ... 277
—Iridium. Dudley. (D.) ... 485
—Iron. Addition agents. Li and Watts ... 343
—Iron. Jacobi and Klein. (D.) ... 278
—Lactic acid. Jordis. (P.) ... 667
—Lead. Mathers ... 714
—Magnetic oxide coating. Winslow. (D.) ....425, 736
—Nickel. Classen. (D.) ... 425
—Nickel. Electrodeposition of. Bennet, Kenny and Duggliss ... 340
—Oxide coatings. (P.) ....667, 668
—Palladium. (D.) ... 425
—Platinum. Thomas. (D.) ... 485
—Reliefs for dies. Rieder. (D.) ... 668
—Spray process. Morcom ... 725
—Spray process. Schnop ... 607
—Tin. Mathers ... 764
—Upon aluminium. Loeb, Mies. (D.). 800
—Zinc from sulphate solutions. Shape and Watts ... 339
—Zinc on iron. McIlroy. (P.)... 479
PLATINUM ... 103
—Alloy with tungsten and molybdenum. Weintraub ... 475
—In gold-silver cupellation beads. Detection. (S.) ... 137
—In Germany ... 94
—In Nevada ... 729
—Assaying for gold and platinum. (S.) ... 480
—Substitute for platinum ... 542
Plumb, A. M. ... 799
Pneumatic-type recording tachometer.... 207
Poidometer ... 206
Polarization potentials. Hitchcock ... 342
Porcupine district, Ont., Canada. Cyanide practice. Parmelee ....567, 636, 674
Porous articles. Refractory. Boeck. (P.) ... 148
Portland cement. Testing. Force. (P.) 194
Portland Gold Mining Co ... 150
Post, William C. ... 542
Potassium chlorate in Norway ... 576
Potassium. Production. Bucher. (P.).. 66
Potassium salts in California ... 722
Potatoes and salt. Rubber from. Chauvenet ... 741
Potentials of mineral electrodes ... 635
Potentials. Polarization. Hitchcock.... 342
Pot-roasting. Savelsberg. Weeks. (P.). 660
Powdered coal. Dunn burner. Roush, 19, 94
Power for electric furnace work. Horry. 332
Power for electrochemical processes. Newbury ... 93
Power for electrochemistry. Baekeland. 563
Power for electrolytic work. Longwell.. 92
Power hoisting. Johnson ... 44
Power in electrolytic copper refining. Addicks ... 91
Power problems in electrochemistry...13, 72, 328, 364
Power transmission economics. Sothman 330
Press. Filter. See filter press.
Pressure air-cooled roaster furnace ... 199
Prime movers for electrolytic generators. Longwell ... 92
Processes. Industrial. Applications of physical chemistry. Rittman.... 475
Producer gas. Cold cleaned for high-temperature regenerative furnaces .. 601
Producer gas from wood waste. Lygo.. 33
Producer gas in glass factories ... 207
Professional obligations of chemists. Whitaker ... 437
Progress. Engineering. How the world pays for ... 144
Prospector. Quantitative blowpiping. Fischer ... 693
Pulverized fuel. Lord. (S.) ... 53
Pulverizer, Hammer-bar ... 358
Pumice in California ... 721
Pump casting. Acid. Anto-corrosive.... 206
Pumps. Humphrey, for Egyptian irrigation department ... 599
Pump. Vacuum, for vacuum heating and vacuum filtration systems ... 795
Pyrometers for molten brass and bronze. Gillett ... 648
Pyrometer. Recording ... 359
Pyrometer. Resistance. For low, intermediate, and high temperatures.. 356
Pyrophoric alloy. Faehr. (P.) ... 660
Pyrophoric alloy. Patent decision ... 218

## Q

QUANTITATIVE blowpiping as an aid to the prospector. Fischer...... 693

## R

RABBLE ARMS. Cooling. Herreshoff. (P.) ... 196
Radiator Tubing. Copper. By electrolysis. Feldkamp ... 67
RADIUM:
—American radium industry and the war ... 61
—Federal-State controversy in Colorado and Utah ... 115
—for the masses ... 780
—from ores. Burfeind. (P.) ... 480
—Hearing at Washington ... 170
—in Canada ... 304
—Prices ... 421
—Quantitative determination. Schlundt. 709
—Radium to uranium ratio in carnotite. 656
—Radiothorium. Meitner. (P.) ... 66
Raht, August ... 277
Rails. Finishing. Temperatures and properties. (S.) ... 594
Rail corrugation. Sellon ... 264
Rail Steel. Changing character ... 21
Rail steels for electric railways. Willox.. 263
Railroad electrification as a relief of economic stresses. Johnson ... 614
Rand, Charles F. ....485, 735
Rare earths. Electrolytic separation. Dennis. (P.) ... 791
Ray Consolidated ... 431
Raymond, Rossiter W. ... 542
Recorder, monitor and precipitator for fume and smoke and an instantaneous thermostat. Strong ... 604
Recording instrument. Chart. Brown.. 208
Refining metals. Elmore, Moebius, Dunton, Thum, Emerson, Smith, Wohlwill. (D.) ... 70
Refining metals. Wohlwill, Craney, Klepetko and Morrow, Frasch. (D.) ... 14
—See also the different metals.
Refractometry. Shook....572, 630
Refractories. High-temperature resistivity. Northrup ... 13

Refractory articles. Glazed. Malm. (P.) 140
Refractory porous articles. Boeck. (P.) 140
Refractory. Zirconia 791
Refrigeration. Absorption refrigerating machine 249
Refrigeration. Compression refrigeration cycle. Macintire 151
Refrigeration. Mechanical. Macintire, 99, 151, 249, 447
Regenerative furnace. Cold cleaned producer gas 601
Regulator. Thury. For electric furnaces 333
Remsen, Ira. Willard Gibbs medal 381
Repairing a crank shaft by autogenous welding. Burrows 662
Research. Central organizations 213
Research. Central organizations. Choate 285
Research department. Scientific Materials Co. 358
Research work in the laboratory and mill. Bleecker 515
Research work, value of. Barton 284
Resistivity. High-temperature electric, of refractories. Alundum 125
Resistivity of brass. Solid and molten. Northrup 161
Resistivity of silver. Solid and molten. Northrup. (S.) 535
Retort discharging machine. Simmonds. (P.) 789
Retort. Zinc. Webster. (P.) 196
Reverberatories. Utilization of hot gases. Williams. (S.) 415
Reverberatory smelting. Copper. Fuel in. Demond. (S.) 781
Revett, B. Stanley 210
Richards, J. W. 210, 485, 667
Richards, R. H. 69, 542, 799
Richardson-Phenix Co. 171, 269
Richmond Forgings Corp. 212
Rigg, Gilbert. Color photography applied to the demonstration of the microstructure of ores 30
Rittinger's law of crushing. (S.) 783
Roaster. Pan. Grates for. Greenawalt. (P.) 660
Roasting. Chloridizing. Ledoux. (P.) 140
Roasting. Cooler for roasted ore. Hanington. (P.) 791
Roasting copper. Nickel matts. Kern and Merris. (P.) 198
Roasting furnace. Air-cooled rabble arm. Wedge. (P.) 532
Roasting furnace. Cooling rabble arms. Herreshoff. (P.) 196
Roasting furnace. Air-cooling. Fowler. (P.) 532
Roasting furnace. Electric heating of air. Wedge. (P.) 660
Roasting furnace. Heat conservation. Wedge. (P.) 413
Roasting. Pot. Savelsberg. (P.) 660
Roasting. Sinter. Weeks. (P.) 660
Roasting. Dwight-Lloyd sintering process. Laws. (P.) 532
Roasting. Sintering. Addition agent. Pretceille. (P.) 531
Roasting. Sintering apparatus. Greenawalt. (P.) 261
Roasting. Sintering apparatus. Plock. (P.) 261
Roasting. Sintering process. Huntington-Heberleien and Dwight-Lloyd. (S.) 782
Roasting. Sinter-roasting processes compared. Norton. (S.) 781
Robbins, P. A. 542
Rochester Mines Co. 677
Rockwell Co., W. S. 354
Rossberg, W. N. 609
Rousch, G. A. 19, 94
Rubber from potatoes and salt. Chauvenet. 747
Rubel, Walter 34
Ruggles-Coles Engineering Co. 360
Russell, James E. 799
Russia. Chemical industry 104
Rutile 657

S

SACCHARINE. Legislation 17
Safety work. A. S. & R. Co. 194
Safety work in chemistry 61
Sampling. Automatic of mill pulp. 799
San Francisco exposition 436
Sanitation control of the city of New York. Lederle 55
Santa, Gertrudis 617
Sawdust for extinguishing fires 105
St. Louis as a field for electrochemistry. Carrier 289
Scales for blast furnaces 123
Schaefer, O. C. 141
Schaffer Engineering & Equipment Co. 206
Scheelite concentrates, determination of phosphorus. Hagmaier 620
Scheelite. Gold-bearing in New Zealand Gudgeon. (S.) 53
School of Mines of Columbia University. Fiftieth anniversary 168, 347
Scientific Materials Co. 358, 793
Screen analysis-graphic record. Speak. (S.) 482
Screen. Self-cleaning for sewage and trade wastes 202
Screen. Research. Wurl 203
Secretaries of national technical societies 13
Section meetings. Local, of national societies 73
Selenium. Addicks 187
Selenium in glass. Sullivan 188
Self-cleaning screen for sewage and trade wastes 202
Selm, L. 735
Sewage. Self-cleaning screen 202
Sharpening files for electrolysis. Gillett (D.) 278
Shaw Electric Crane Co. 482, 729
Sherwin-Williams Co. dryer 272
Ship building. Scotch 394
Siemens-Halske 62
Sight flow indicator 171
Silfrax 710
Silica brick and clay brick. Relative thermal conductivity. Marshall. 74
Silica. Determination in iron ores. Wurzel 430
Silicidized carbon. Tone 710
Silico-manganese 355
SILVER:
—Chloridizing at Silver City, Utah 757
—Cobalt ores. Dyckerhoff. (P.) 412
—Flotation antimonial silver ore. Campbell. (P.) 198
—Parting of silver and gold. Moebius. (D.) 69
—Refining. Thum. (D.) 70
—Resistivity. Solid and molen. Northrup. (S.) 535
—Sterling. Gleason. (P.) 65
—Sulphide. Electric properties of. Fitz Gerald 341
—Sulphide ores. Cyanidation. Linton. (S.) 349
— See also Gold and Silver.
Simpson, K. M. 541
Sintering. Addition agent Pretceille (P.) 531
Sintering apparatus. Greenawalt. (P.) 261
Sintering apparatus. Plock. (P.) 261
Sintering. Dwight-Lloyd. Laws. (P.) 532
Sintering. Huntington-Heberlein and Dwight-Lloyd processes. Dwight. (S.) 782
Sintering iron-bearing materials. Klugh. (S.) 197
Sinter-roasting processes compared. Norton. (S.) 781
Sinter-roasting. Weeks. (P.) 660
Skin effect in carbon electrodes. Hinckley 223
Skinner, J. D. 210
Slag. Molten. Utilization of heat 651
Slag Power Co. 651
Slide rule for chemists. Lee 201
Slide rule. Frameless 423
Slime agitator. Marcy (P.) 195
Slime filter. Butters. (P.) 530
Slime filter. Ridgway. (P.) 659
Slime filter. Trent. (P.) 658
Smith Gas Power Co. 601
Smith, E. A. Cappellen 338
Smith, W. A. 347
Smoke recorder, monitor and precipitator. Strong 604
Soda process. Ammonia. Theory. Mason 571
Soda process. Leblanc, Solvay. Electrolytic. Baekeland 561
Sodium amalgam. Electric conductivity. Vanstone 14
Sodium chloride electrolysis. Baekeland. 561
— Diaphragm cell. Byrnes. (P.) 534
—Diaphragm cell. Dow. (P.) 480
— Mercury cathode. Le Sueur 61
Sodium cyanide. Synthetic production Matignon 163
Sodium. Production. Bucher. (P.) 66
Solidification of metals from liquid state Desch. (S.) 595
Solubility of orthophthalic acid. Rivett and Rosenblum 14
Solutions. Handling chemical solutions in quantity. Phelps 391
Solvay Process Co. 684
Soot fall in Pittsburgh 247
Sothman, P. W. Portrait 330
Specifications. British engineering standards 652
Spicer, H. N. 69
Sponge iron. Use of peat Anderson and Odelstierna 728
Spray process of metallic coatings. Morcom 725
—Schoop 607
Stack of blast furnace. Construction. Johnson 451, 497
Stamp mills and milling notes Storms 225
Stamps. Nissen. For tin ore (S.) 108
Staver, W. H. [illegible]
Steam. Effect upon magnesite brick Youngman 620
Steam. Superheated, on locomotives. 443
Stearns, T. B. 210
Steinmetz, C. P. Portrait 320
Stephens Adamson Mfg. Co. 169
Sticht, R. C. 69, 542
Still. Water. Link 706
Storm, C. G. 496
Stoves. Blast furnace. Johnson 395
Stratton's Independence 542
Stratton's Independence, Ltd., Cripple Creek, Col. 542, 635
Struthers, J. 476
Sturakoff Laboratories 200, 306
Sturtevant Mill Co. 358
[illegible]
[illegible]
—[illegible] 4[illegible]6
—[illegible] 446
—Removal of [illegible]
—[illegible] [illegible]
Sulphur in [illegible] [illegible]
—Removal from [illegible]. H[illegible] [illegible]
—Valuation of [illegible] sulphide [illegible]. Wedge (P.) [illegible]
Sulphurous acid and fumes from smelters. Wagner [illegible]
—Mammoth smelter [illegible] [illegible]
Supplies. [illegible] Hdw. Co. 68
Surface combustion. Bone [illegible]
Symposium on the practical side of electrochemical investigation [illegible]
Synopsis of recent chemical and metallurgical literature. 53, 137, 197, 262, 348, 414, 480, 534, [illegible]

T

TABLE. Round at Great Falls. Crowfoot. (S.) [illegible]
Tachometer. Electric 357
Tachometer. Pneumatic-type recording 207
Tango at the Chemists' Club [illegible]
Tanks. Acid. Mastic lining 353
Tank. Parral. Leaching copper ores [illegible]
Tar from coal gas. Wagner. [illegible]
Tar. Removal from Gas. Steere 775
Tate, Jones & Co. 54, 264, 740
Taylor, J. B. [illegible]
Telluride disaster [illegible]
Temperature control by electric thermostat. Geissinger [illegible]
Temperature of ingots. New method for determining. Homan [illegible]
Temperature measuring instrument. Combination portable for low, intermediate and high temperatures. 356
Testing. Electric. Manual 302
Testing set. Combination portable 356
Thayer, B. B. [illegible]
Thermal Syndicate [illegible]
Thermit in municipal repair plant [illegible]
Thermocouples. Base metal 200, [illegible]
Thermopile. Marschall [illegible]
Thermostat. Electric. Geissinger [illegible]
Thermostat. Instantaneous and fume and smoke recorder, monitor and precipitator. Strong [illegible]
Thomas, Benjamin F. Obituary 542
Thomas, Kirby [illegible]
Thomson, H. N. [illegible]
Thomas C., Arthur H. [illegible]
Thoria from monazite sand. Baskerville (P.) [illegible]
Thorium. Arsem. (P.) [illegible]
Thorium. Radio. Meitner (P.) [illegible]
Thornton, W. P. 426
Timber products. Dry kiln [illegible]
Thwing Instrument Co. [illegible]
TIN:
—Alloys with copper and zinc. Hoyt [illegible]
—Assay of tin ores and concentrates. Hutchin. (S.) [illegible]
— Wraight and Teed. (S.) [illegible]
—Concentration at Geevor Mill, Cornwall. (S.) [illegible]
—Copper-tin-lead alloys. Blow 462
—Crushing tin ore with Nissen stamps. (S.) [illegible]
—Detinning. Savage. (P.) [illegible]
—Detinning. Von der Linde. (P.) [illegible]
—Electrodeposition. Mathers [illegible]
—From scrap. Hoskins. (P.) 413
—in cassiterite [illegible]
—in iron. Rossi. (P.) [illegible]
—Metallurgy. Cowan [illegible]
—Plating. Mathers [illegible]
—Tin-zinc-copper alloys. Blow 464
Titanium Alloy Manufacturing Company [illegible]
Titanium carbide. Rossi and Meredith (P.) 413
Titanium nitride in steel. Comstock [illegible]
Titanium manufacture and alloys. Kraus (P.) 352
Titration. Electrometric. Ziegel 705
Toch Bros. 360
Tonopah Mining Co. [illegible]
Towers. Sulphuric acid. Schliebs (S.) [illegible]
Transmitting indicating and recording system. Long distance [illegible]
Transvaal Chamber of Mines 104, 475, 542, 649
Transvaal gold production [illegible], 475, 542, [illegible]
Trauerman, C. J. 210
Treglown, J. B. [illegible]
Tropenas converters vs. electric furnaces for the manufacture of steel castings. Muntz [illegible]
Trust program. The government's [illegible]
Tube mill end liners. Pyles. (S.) [illegible]
Tube mill. Hardness of ores. Blyth (S.) [illegible]
Tube milling in all-slime cyanide practice. Portland [illegible]
Tubing. Copper by electrolysis. Feldkamp [illegible]
Tulsa Spelter Co. [illegible]
TUNGSTEN: [illegible]
—Alloy with nickel [illegible]
—Ductile. Moore [illegible]

TUNGSTEN: (Continued.)
——Ductile. Patent .................... 108
——Ductile. Schwartzkopf and Burgstaller. (P.) .................... 480
——in England .................... 650
——in high-speed steels. Arnold and Reed .................... 415
——Ore production .................... 152
Turboblower .................... 312
Turnock, L. C.................... 542
Turpentine. Gum and wood............ 95
Turpentine wood industry. French and Withron ....................61, 95

## U

UNIT-COST keeping in metallurgical works. Haynes..............449, 614
——Ashby .................... 549
U. S. Geological Survey..41, 188, 198, 253, 360, 419, 424, 440, 539, 543, 623, 635, 661
U. S. Smelting, Refining & Milling Co.. 432
U. S. Steel Corporation. Dissolution suit. 671
U. S. Steel Corporation. Report........ 214
Uranium from ores. Burfeind. (P.).... 480
Uranium. Radium to uranium ratio in carnotite .................... 656
Utah Copper Co...............169, 432, 745
Utah. Metal output value...........424, 440

## V

VACUUM cleaning for laboratories..... 68
Vacuum pan test. Kerr................ 81
Vacuum pump for laboratory cleaning. Leiman .................... 68
Vacuum pump for vacuum heating and vacuum filtration systems....... 795
Vail, G. M.................... 210
Valves. Air .................... 232
Valve. High-pressure gas.............. 794
Valve. Hydraulic reducing ............ 541
Valve. Reversing. George. (P.)...... 727
Valves. Steam .................... 311
Vanadium in brass. Dunn and Hudson. (S.) .................... 594
Vanadium from ores. Burfeind. (S.)... 480
Vanadium. Production. Boericke. (P.) 659
Van Arsdale, G. D.................... 277
Vargöns Company .................... 355
Vismera pure iron.................... 306
Vitreosil .................... 608
Volatilization of metals as chlorides.... 71, 137, 414
Von Isakovics, Alois.................... 426
Vulcanite Paving Co.................... 353

## W

WADDELL, G. F.................... 69
Wage problem in steel industry......... 281
Wagner Electric Co.................302, 436
Wall Mfg. Supply Co., P................ 379
Wallaroo & Moonta Co.............. 367
War and American financing abroad.... 612
War and American manufacturers....... 663
War and American radium industry..... 612
War and British engineering industries.. 650
War and British engineering trades...... 725
War and chemical industry..........546, 551
War and metallurgical development..546, 617, 670
War. European .................... 545
Water. Electrolysis. Garuti. (D.)..... 544
Water. Electrolysis. Huber. (D.)...... 610
Watermarks, Disappearing, on paper. Goodchild and Bond. (D.)..... 736
Waterproofing fabrics. Electrolytic. (D.) 610, 800
Water softening .................... 788
Water still. Link.................... 796
Webber, Samuel S.................... 609
Weber, Peter J.................... 799
Weeks, F. D.................... 277
Weighing and regulating the continuous flow of materials on conveyors.. 206
Weintraub, Exechiel .................... 475
Welding. Autogenous. Crank shaft. Burrows .................... 662
Welding copper and nickel............. 619
Welding, Electropercussive. Chubb and Skinner .................... 713
Welding. Oxy-acetylene .............. 66
Welding. Oxy-acetylene. Strength of welds .................... 598
Welding powder for iron and steel. Eisengraber. (P.) ........... 351
Welding broken crank shaft. Burrows.. 662
Welfare work. A. S. & R. Co.......... 194
Welfare work in chemistry.............. 61
Welfare work in the steel industry...... 428
Wellman-Seaver-Morgan bin............ 120
Werner & Pfleiderer Co................ 733
Western metallurgical field..10, 77, 149, 221, 286, 365, 431, 492, 555, 616, 676, 743
Wheeler, A. E.................... 210
Whitaker, M. C. Portrait............... 55
White lead. Experiments. Owens...... 342
White lead. Manufacture. Stewart. (P.) 412
Whittlesey, Curtis E. Obituary........ 734
Wilbur, Robert E.................... 799
Wire, Aluminium. Electrolytic insulation. Chubb and Skinner............ 712
Wood, J. .................... 210
Wood turpentine industry. Wood, French and Withrow ................61, 95
Wood waste. Producer gas from. Lygo.. 33
Wood waste utilization. Bath processes. Teeple .................... 35
Wool. Electrolytic extraction of oil. Burton. (D.) .................. 609
Worthington Pump Co, Hy. R........... 482

## Y

YARNALL-Waring Co.... ........310, 702
Youtsey, F. S.................... 609
Yttrium by electrolysis. Dennis. (P.).. 791

## Z

ZINC:
——Alloys with copper and tin. Hoyt.. 644
——Ammonia-carbon dioxide process for complex ores. Bretherton. (S.). 655
——Ammonia process. Bretherton. (P.). 139
——by electrolysis of fused salts. Wang. (S.) .................... 481
——Chloridizing complex sulphide ores. Forland. (P.) .............. 64
——Chlorination in Utah............... 222
——Coatings on iron. McIlroy. (P.).. 479
——Collecting zinc oxide fumes. Reynolds. (P.) .................. 140
——Concentrates in Joplin............. 440
——Concentration of complex sulphides from Mary Murphy..21, 157, 217, 243
——Controlling formation of zinc dust. Roitzheim. (P.) .............. 530
——Determination at Broken Hill. (S.). 138
——Determining zinc in bronze coins. Rose .................... 326
——Dry chloridization of ores. Malm.. 128
——Electric. Johnson ..............360, 494
——Electric furnace with integral condenser. (P.) ................ 789
——Electric. Prospects in British Columbia .................... 425
——Electric. Specketer. (P.).......... 531
——Electrolytic. Borchgrevink.......... 381
——Electrolytic. Molstad .............. 548
——Electrolytic. Richards ............ 339
——from sulphate solutions. Shape and Watts .................... 339
——Flotation. Selective. Horwood process. (S.) ......................350, 414
——Electrostatic separation of zinc and iron at Midvale. (S.).......... 782
——Igneous concentration of metallic values from mixed sulphides. Clerc ................250, 307, 490
——in Kansas and Arkansas............ 419
——Isherwood process. (P.).......351, 789
——Losses in mining, milling and smelting. Lyon and Arentz. (S.)... 655
——Manufacture and properties. Stone. 643
——Magnetized roasted zinc and iron ores. Brooks. (P.)............ 352
——New source of ore. Mereness...... 285
——Oil flotation at Butte and Superior. 222
——Production in 1913................ 253
——Progress in metallurgy in 1913...... 4
——Recovery from refuse. Parish. (P.). 789
——Retort. Webster. (P.)............. 196
——Retort discharging machine. Simmonds. (P.) ................ 789
——Separating zinc blende and barytes. Greenstreet. (P.) ............ 659
——Sintering retort residues. Jones. (P.). 790
——Smelting under pressure. Cutten. (P.). 64
——Sublimed zinc concentrate by the use of the fuel value of sulphides. Clerc .................... 307
——Zinc-tin-copper alloys. Blow........ 464
——World's output .................. 440
——See also Complex Ore Problem.
Zinc oxide. Manufacture. Singmaster. (P.) .................... 790
Zirconium production. Kuzel and Wedekind. (P.) .................. 260
Zirconia. Refractory .................. 791

# AUTHORS' INDEX

A
ADDICKS, LAWRENCE. Impurities in cathode copper .......... 706
——The power problem in electrolytic refining of copper .......... 91
Ashby, Ernest G. Cost accounting as a branch of accounting, and the work of accountants.......... 549
Austin, L. S. Is there a complex-ore problem? .......... 300

B
BAEKELAND, L. H. Some aspects of industrial chemistry .......... 557
Bancroft, W. D. Electrolytic flames.... 334
Barrier, Edw. A. Extinguishing of fires in volatile liquids .......... 105
Barton, C. J. Value of research work.. 284
——Accelerators for gasoline gas plants 419
Baskerville, Chas. Factors involved in opening up the field of unused elements .......... 181
Bell, R. C. Is there a complex-ore problem? .......... 297
Bennett, C. W., Kenny, H. C., and Duggliss, R. P. Electrodeposition of nickel .......... 340
——And Davison, A. W. Electrolytic deposition of brass .......... 340
Beutner, R. Determination of free energy .......... 342
Bjorkstedt, William. The induction furnace—its efficiency and refining capabilities .......... 146
Blake, K. H., and M. de Kay Thompson. Preparation of pure calcium carbide .......... 779
Bleecker, Warren F. Hydrometallurgy—Joys of its theory, woes of its practice .......... 8
——Is there a complex-ore problem?.. 375
——Research work in the laboratory and mill .......... 515
Blow, Allmand M. Three metal bronzes. 461
Boeck, Percy A. The Kieselguhr industry .......... 109
Bretherton, S. E. Is there a complex-ore problem? .......... 374
Brickenstein, Townsend and Byrnes. Digest of electrochemical U. S. patents ..69, 142, 210, 377, 425, 485, 543, 609, 667, 736, 7[illegible]
Brophy, Oscar. True chemical energies of combination .......... 674
Brown, W. D. Analysis of natural gas 168
——Determination of carbon in iron and steel .......... 390
Burger, Alfred. New filter press. ..61, 101
Burgess G. K., and Foote, P. D. The emissivity of metals and oxides 525
Burrows, C. H. Repairing a crank shaft by autogenous welding .......... 662
Byrnes, Brickenstein and Townsend. Digest of electrochemical U. S. patents ..69, 142, 210, 277, 425, 485, 543, 609, 667, 736, [illegible]99

C
CALHANE, D. F., and Wheaton, T. C. Fine-meshed brass gauze as a substitute for platinum in electroanalysis .......... 87
Canby, R. C. Is there a complex-ore problem? .......... 301
Carrier, C. F. Possibilities of St. Louis as a field for electrochemistry.. 289
Chatterton, R. M. Power problems in electrochemistry .......... 364
Chauvenet, Regis. Indeterminate cases in mixing ores for calculation of furnace charges .......... 626
——Potatoes and salt.......... 741
Choate, Parker C. Central research organizations .......... 285
——Is there a complex-ore problem?.. 430
Chubb, L. W., and C. E. Skinner. Electrolytic insulation of aluminum wire .......... 712
Chute, H. O. Patent Processes for Making Casing Head Gasoline.......... 147
——Electropercussive welding .......... 713
Clark, E. B. Electric furnaces for steel making .......... 336
Clerc, F. L. The igneous concentration of metallic values from mixed sulphides ..........250, 307, 490
——Is there a complex-ore problem?.. 471
Clevenger, G. H. Is there a complex-ore problem? .......... 298
Collins, Geo. E. Concentration of complex sulphide ore from the Mary Murphy mine .......... 243
——Is there a complex-ore problem?.. 298
Comstock, George F. Titanium-nitride in steel .......... 577
Cornell, Sidney. Heat balance of the blast furnace .......... 747
Corse, W. M., and Skillman, V. Manganese bronze .......... 113
Croasdale, Stuart. Is there a complex-ore problem? .......... 369
Czaplewski, Prof. Hygiene and the use of ozone for ventilation .......... 254

D
DARY, GEORGE. Nitrates by electrolysis of peat.......... 107
Davison, A. W., and Bennett, C. W. Electrolytic deposition of brass. 340
Deacon, R. W. Metal inventory in an electrolytic copper refinery.... 338
Dolbear, Samuel H. Chemical resources in California .......... 7[illegible]0
Dorr, J. V. N. Grinding ore for cyanidation: A suggested modification for all-sliming practice .......... 67[illegible]
Duggliss, R. P., Bennett, C. W., and Kenny, H. C. Electrodeposition of nickel .......... 340

E
EYE, C. M. The development of modern cyanide practice .......... [illegible]

F
FISCHER, SIEGFRIED, JR. Concentration of carnotite and the work of the Bureau of Mines .......... 146
——Quantitative blow-piping as an aid to the prospector ..........693, 771
Fitz Gerald, F. A. J. Quotations from classics .......... 216
——Economies of electric furnace operations .......... 331
——Electric properties of silver sulphide .......... 341
Foote, P. D., and J. K. Burgess. The emissivity of metals and oxides 525
French, E. H., and Withrow, James R. The present status of the wood turpentine industry .......... 6[illegible] 95

G
GAHL, R. Leaching of copper tailings 338
George, R. D. Is there a complex-ore problem? .......... 373
Getman, Frederick H. Reproducibility of the copper electrode .......... 706
Godbe, E. L. Is there a complex-ore problem? .......... 302
Godshall, L. D. Is there a complex-ore problem? .......... 47[illegible]
Gonzalez, L. R., and M. De Kay Thompson. Preparation of true calcium carbide .......... 779
Goodrich, R. R. The hydro-electrolytic treatment of copper ores .......... 338
Guess, H. A. Is there a complex-ore problem? .......... 300

H
HAMMAHER, E. W. The determination of phosphorus in phosphor-bronze 524
——The determination of phosphorus in Scheelite concentrates .......... 620
——Copper in babbitt metal .......... 753
Haldane, Wm. G. Is there a complex-ore problem? .......... 374
Hall, J. Howe. The metallurgical engineer in the steel works .......... 503
Hansen, C. A. Electric steel castings 335
Harden, John. Efficiency and refining possibilities of the induction furnace .......... 216
——Electric iron smelting at Hardanger in Norway .......... 82, 223, 444
Hardinge, H. W. Cyanide practice in the porcupine district .......... 674
Haynes, Justin H. Notes on unit cost keeping in metallurgical work .......... 449
——Cost accounting and the work of accountants .......... 614
Hering, Carl. Physical versus chemical actions in furnaces .......... 439
——Energy of vaporization of carbon 526
Herreshoff, J. B. F., etc. Report of chemical and dyestuff committee 753
Hesse, B. C., etc. Report of chemical and dyestuff committee .......... 753
——Some economic aspects of industrial chemistry .......... 754
——The European war and the chemical industries of this country .......... 55[illegible]
Hinckley, A. T. Skin effect in carbon electrodes .......... 22[illegible]
Hitchcock, C. N. Polarization of single potentials .......... 34[illegible]
Holmes, J. A. Policy of the Bureau of Mines .......... 334
Homan, John C. A suggestion of a new method for determining the temperature of ingots .......... [illegible]4
Horry, W. S. Power for electric furnace work .......... [illegible]
Hoskin, A. J. Is there a complex-ore problem? .......... 3[illegible]
Hoyt, Samuel L. Copper-rich Kalchoids 30

IONIDES, S. A. Is there a complex-ore problem? 375, 673

JAYNE, D. W., etc. Report of chemical and dyestuff committee 753
Jeffries, Zay. Notes on the Gran-annular electrical furnace 154
Johnson, J. E., Jr. Handling the raw materials at the iron blast furnace 44, 117
——The boiler plant of the blast-furnace 171
——Oxygen in cast iron 192
——Blast-furnace blowing apparatus. 230, 311
——Blast furnace stoves 395
——The construction of the blast furnace stack 451, 497
——The gas from blast furnaces, its cleaning and utilization 685, 760
——Firebrick 672, 740
Johnson, Woolsey McA. Electro-metallurgy of iron and steel 165
——Quotations from classics 216
——Is there a complex-ore problem? 370
——Railroad electrification as a relief of economic stresses 614
——and Sieger, Geo. N. History of electric furnaces 41

KALMUS, T. Cobalt and cobalt alloys. 184
Keedy, Dyke V. Concentration of complex sulphide ore from the Mary Murphy mine 157
Kenny, H. C., Bennett, C. W., and Buggliss, R. P. Electrodeposition of nickel 340
Kerr, E. W. Test of a vacuum pan 81
Kimber, H. P. Accelerator for gasoline gas plants 740
Kithill, K., and Moore, R. B. Concentration of carnotite by wet and dry methods 89
Kowalke, O. L. Base-metal thermo-couples 705

LACROIX, H. Electrolytic refining of the precious metals 441
Lass, W. P. Advantages of Southeastern Alaska for hydroelectrochemical industries 337
Lederle, E. F. Sanitation control of the city of New York 55
Lee, Harvey R. A new chemists' slide rule 201
Le Sueur, E. A. Electrolysis of chloride solutions with a mercury cathode 61
——Recent developments in commercial explosives 55
Li, N. H., and Watts, O. P. Effect of addition agents in the electrodeposition of iron 343
Lieber, Hugo. The manufacture and uses of Blaugas 153
Lincoln, Francis Church. Nevada state mine rescue and first aid meet 615
Longwell, H. E. Prime movers for electrolytic generators 92
Lundell, G. E. F. New method for the determination of free cyanide in electroplating solutions 340

McQUIGG, C. E. Blast-furnace blowers. 286
Macintire, H. J. Mechanical refrigeration 99, 151, 249
——Chemical and industrial applications of mechanical refrigeration. 447
Mainwaring, Wm. D. The heat treatment of steel results obtained by spring makers and steel works treatment 365
Malm, John L. Hydrometallurgy—Joys of its practice, woes of its theory 75
——Dry Chlorination of Ores 128, 780
Mantius, Otto. The evaporator problem in electrochemical plants 715, 722
Marble, H. M., and Mathers, F. C. Electrodeposition of cadmium 339
Marsh, W. Judson. Electro-analysis of nickel 709
Marshall, E. I. Railway track cell 342
Marshall, S. M. Relative thermal conductivity of silica and clay brick 74
Martin, Al. H. Treating sulphurous fumes at the Mammoth smelter 769
Mason, William. A new theory of the ammonia soda process 571
Mathers, Frank C. Electrodeposition of lead and tin 714
——and H. M. Marble. Electrodeposition of cadmium 339
Matheson, William J. The European war and the chemical industries of this country 552
Matignon, Camille. Industrial synthetic production of sodium 163
Matos, Louis J. The European war and the chemical industries of this country 553
Matthews, J. Merritt, etc. Report of chemical and dyestuff committee 753
Mereness, H. A. A new source of zinc ore 285
Metz, H. A., etc. Report of chemical and dyestuff committee 753
Meyer, H. Conrad. Zirconia, a new refractory 791
Miller, W. Lash. Electroplating 714
Molstad, R. Electrolytic zinc 548
Moltkehausen, I. J. Electrochemical progress in Norway in 1913 124
Monell, Ira F. Is there a complex-ore problem? 490
Moore, R. B., and Kithil, K. Concentration of carnotite by wet and dry methods 89
Motherwell, Harry A. B. Microstructure of raw and manufactured copper 8
Motherwell, W. A new design of filter press 284
——Is there a complex-ore problem? 490, 548, 673
Muntz, G. Tropenas converters versus electric furnaces for the manufacture of steel castings 379

NEWBURY, F. D. Electrical equipment for electrochemical processes 93
Nichols, William H. The European war and the chemical industries of this country 551
Northrup, Edwin F. A new high-temperature furnace 31
——Cascade attachment for graphite furnace 305
——Electric conduction at high temperatures 340
——Resistivity of brass; solid and molten 161
——High-temperature resistivity of refractories. A new method of measuring, with results for alundum 125

O'CONNOR, JOHN, JR. Soot-fall study of Pittsburgh 247
Owens, R. S. Experiments on white lead 342

PALMER, R. C. The possibilities of hardwood distillation on the Pacific Coast 623
Parks, H. M. Is there a complex-ore problem? 370
Parmelee, H. C. Concentration of complex sulphide ore from the Mary Murphy mine 21, 217
——Ore treatment at Cobalt, Ont. 467, 507
——Cyanide practice in the Porcupine District, Ont. 567, 636, 674
Pease, O. D. A., Young, C. D., and Strand, C. H. Heat treatment of steel castings 193
Pentland, W. J. Grinding ore for cyanidation: A suggested modification for all-sliming practice 621
——Tube milling in all-slime cyanide practice 750
Phelps, C. C. A convenient method for handling chemical solutions in quantity 391
Pierce, D. T. The dependence of industries on chemistry 614
Pulsifer, H. B. Present status of the Fink furnace 731

RANDALL, JOHN. A successful method of amalgamating in cyanide solution 248
Reed, Charles S. Firebrick 672, 740
Rennerfelt, Ivar. The induction furnace for steel melting and refining 74
——The electric arc furnace and the development of the steel-casting industry 581
Richards, Jos. W. Electrolytic zinc 339
Richards, Robert H. Is there a complex-ore problem? 370
Richardson, E. A. Effect of pickling upon the corrosion of iron 759
Rittman, Walter F. The application of physical chemistry to industrial processes 475
Roeber, E. F. Some economic and aesthetic aspects of electrochemistry 344
Rogers, Allen, etc. Report of chemical and dyestuff committee 753
Roush, G. A. The Dunn pulverized coal burner 19

SCHLUNDT, HERMAN. Quantitative determination of radium 709
Schmelz, Ernest M. Keeping an electric furnace hot during periods of idleness 216
Seibird, Geo. H. Is there a complex-ore problem? 373
Shape, A. C., and Watts, O. P. Addition agents in the deposition of zinc from zinc sulphate solution 339
Shook, G. A. Refractometry 572, 630
Sieger, George N., and Johnson, W. McA. History of electric furnaces 41
Siever, H. L. An apparatus for making the flash and fire tests of lubricating oils 188
Skillman, V., and Corse, W. M. Manganese bronze 113
Skinner, C. E., and L. W. Chubb. Electrolytic insulation of aluminium wire 712
——Electropercussive welding 713
Skinner, Lewis B. Hydrometallurgy—Joys of its theory, woes of its practice 8
——Is there a complex-ore problem? 371, 548
Smith, E. A. Capellen. The development of copper leaching and electrolytic precipitation at Chuqincamata, Chile 291, 338
Sothman, P. W. Power transmission economics 330
Spicer, H. N. Cyanide practice in Porcupine district 742
Steere, F. W. An electrical process for detarring gas 775
Steinmetz, C. P. Characteristics of electrical energy as affecting chemical industries 329
Stone, I. F. Coal tar colors in America. 679
——Report of chemical and dye-stuff committee 753
Storey, O. W. Electrolytic iron 342
——Study of the annealing process for malleable castings 383
Storms, Wm. H. Some notes on stamp-mills and milling 225
Strand, C. H., Pease, O. D. A., and Young, C. D. Heat treatment of steel castings 193
Strong, W. W. A fume and smoke recorder, monitor and precipitator, and an instantaneous thermostat. 604
Swart, W. G. Is there a complex-ore problem? 297
Sweetland, E. J. The clam-shell filter press 57

TAFT, H. S. Chemistry of salt water cement 26, 76
Teeple, John E. Utilization of Wood waste, bath processes 35
Thatcher, Chas. J. Definition of alloys. 430
Thompson, M. DeKay. Preparation of pure calcium carbide 779
Thomson, Francis A. Is there a complex-ore problem? 371
Toch, Maximilian. The European war and the chemical industries of this country 552
Tone, F. J. Silicidized carbon-silfrax 710
Townsend. Byrnes and Brickenstein. Digest of electrochemical U. S. patents 69, 142, 210, 277, 425, 485, 543, 609, 667, 736, 799
Traphagen, F. W. Is there a complex-ore problem? 300
Turnbull, R. Electric furnace regulators 333

VOM BAUR, C. H. Efficiency and refining possibilities of the induction furnace 217
——Heavy Mexican oil as fuel 491
Vosmaer, A. Notes on ozonator designs. 36
——Light from unconsumed electrodes 377

WAGNER, FRED H. The late Walther Feld 514
Wagner, T. B. The effect of legislation upon chemical industries 15
Walters, H. E. Rapid method for the determination of chromium in pig iron, cast iron and steel 310
Watts, O. P., and Shape, A. C. Addition agents in the deposition of zinc from zinc sulphate solution 339
——and Li, N. H. Effect of addition agents in the electrodeposition of iron 343
Wheaton, T. C., and Calhane, D. F. Fine-meshed brass gauze as a substitute for platinum in electroanalysis 87
Whitaker, M. C. Some professional obligations 437
Wiard, Edward S. Is there a complex-ore problem? 301
Withrow, James R., and French, E. H. Wood turpentine industry 61, 95
Wurzel, S. Rapid evaporation of solution in the determination of silica and alumina in iron ores 430

YOUNG, C. D., Pease, O. D. A., and Strand, C. H. Heat treatment of steel castings 193
Youngman, R. H. The effect of steam upon magnesite brick or calcined magnesite 620

ZIEGEL, HENRY. Electrometric titration 705

# Metallurgical and Chemical Engineering

A Consolidation of ELECTROCHEMICAL AND METALLURGICAL INDUSTRY and IRON AND STEEL MAGAZINE

VOL. XII NEW YORK, JANUARY, 1914 No. 1

PUBLISHED MONTHLY BY THE

McGraw Publishing Company, Inc.

JAMES H. MCGRAW, President.
C. E. WHITTLESEY, Secretary and Treasurer.
239 West 39th Street, New York.
TELEPHONE CALL, 4700 BRYANT.
CABLE ADDRESS, METCHEM, NEW YORK.

WESTERN OFFICE................421 Boston Bldg., Denver, Colo.
CHICAGO OFFICE..........................Old Colony Building
PHILADELPHIA OFFICE................Real Estate Trust Building
LONDON OFFICE............Hastings House, Norfolk St., Strand

E. F. ROEBER, PH.D., Editor.
H. C. PARMELEE, Western Editor.

J. M. MUIR, Manager.

*Yearly subscription price for United States, Mexico and United States dependencies, $2.00; for all other countries, $2.50. (European exchange, 10 shillings, 10 marks, 12.50 francs.)*

Copyright, 1913, by the McGraw Publishing Company, Inc.

Entered as Second-Class Matter at the Post Office at New York, N. Y., under the Act of Congress, March 3, 1879.

NEW YORK, JANUARY, 1914

CONTENTS.

EDITORIAL:

The Business Outlook........ 1
Progress in Copper Metallurgy........ 2
Progress in Gold and Silver Metallurgy, 1913........ 3
Developments in the Metallurgy of Zinc, 1913........ 4
Developments in Concentration Methods........ 5
Showing of the Iron Industry in 1913........ 6

READERS' VIEWS AND COMMENTS:

Microstructure of Raw and Manufactured Copper. By Harry A. B. Motherwell........ 8
Hydrometallurgy—Joys of Its Theory, Woes of Its Practice. By Lewis B. Skinner and Warren F. Bleecker........ 8
Western Metallurgical Field........ 10
Iron and Steel Market........ 12
The Non-Ferrous Metal Market........ 13
Symposium of Paper on the Power Problem in the Electrolytic Deposition of Metals........ 13
Meeting of Secretaries of National Technical Societies........ 13
The Faraday Society........ 13
The Effect of Legislation Upon Chemical Industries. By T. B. Wagner........ 15
The Dunn Pulverized Coal Burner. By G. A. Roush........ 19
Concentration of Complex Sulphide Ores from the Mary Murphy Mine. By H. C. Parmelee........ 21
Chemistry of Salt Water Cement. By Harrison S. Taft........ 26
Color Photography Applied to the Demonstration of the Microstructure of Ores. By G. Rigg........ 30
Copper-Rich Kalchoids........ 30
A New High Temperature Furnace. By E. F. Northrup........ 31
Notes on Chemistry and Metallurgy in Great Britain........ 33
Utilization of Wood Waste; Bath Processes. By John E. Teeple........ 35
International Electrical Congress........ 36
Ozonators. By A. Vosmaer........ 36
History of Electric Furnaces. By W. McA. Johnson and George N. Sieger........ 41
Handling Raw Materials at the Blast Furnace. By J. E. Johnson, Jr........ 44
SYNOPSIS OF RECENT CHEMICAL AND METALLURGICAL LITERATURE........ 53
New York Meeting of American Institute of Chemical Engineers with Abstracts of Papers by E. F. Lederle, E. A. LeSueur, E. J. Sweetland, E. A. LeSueur, A. Burger, A. Vosmaer, E. H. French and James R. Withrow........ 55
Analyses of Coals in the United States........ 62
A Large Electric Steel Furnace Installation........ 62
RECENT CHEMICAL AND METALLURGICAL PATENTS........ 63
Oxy-Acetylene Welding and Cutting........ 64
Laboratory Mill........ 64
A New Electrolytic Process for the Production of Flat Perforated Copper Tubing for Radiators........ 65
Laboratory Vacuum Cleaning........ 68
Monel Metal........ 68
PERSONAL........ 69
DIGEST OF ELECTROCHEMICAL U. S. PATENTS........ 69
BOOK REVIEWS........ 70

## The Business Outlook

There is a fortune in store for the inventor who can make a perfect looking glass. Most mirrors reflect the bleak and garish rays and make a person look worse than he really is.

A shrewd New England business man recently told us a story in point. He was feeling tired and nervous one day as he sat in a barber's chair—he could not get people to pay him what they owed him, the government were spoiling business, his workmen would not work, his lunch was not digesting, and it was raining outside. As the barber asked him whether he wished a tonic for his hair, he was shocked and grieved at the aged countenance reflected in the grim mirror. He looked at the barber's face in the glass. This fat and eupeptic representative of the race that conquered all Gaul and carried the victorious eagles to Ultima Thule, looked a sick, fat, flabby-faced, chicken-hearted degenerate son of the heroic masters of the world. Then he looked at the tonsorial artist directly. His poor weak brain could hardly believe his eyes. The barber he saw was really a well-nourished, charming man, who, with an education, might have served his adopted country well as a diplomat. The business man had the saving grace of a keen sense of his own limitations. He said to himself, said he: I am a poor mutt. The mirror is a darned poor mirror, and the mirror is a deus-ex-machina. At all events he quit worrying and sensibly went to work.

Now what is known as a business tone and financial sentiment has periods of distortion of view just as did this business man. Things are never as they seem, and things never seem as they are. Every perception contains truth and falsity. For instance, a year ago the metallurgical concerns of this country were running at full blast and prices of metal were high. Now the reverse is too true. People were then optimistic in the main. Now the reverse is true.

There have been many events that have tended to depress economic values—the Balkan war, the Mexican trouble, and in this country the long delay of tariff and currency legislation, and above all the poor corn crop of 1913. But if in holding the mirror up to industry we conclude that things are in a bad way, are we not making the same mistake as our business friend did? Let us ask ourselves how good are things.

About the only good thing we know of in industry is honest work and sincere intelligence. Intelligence is the faculty that gives us a knowledge of facts and tells how to foresee the coming of facts. While the unintelligent majority is wasting things, the intelligent minority is saving things. There are people in all classes, the aristocrats of democracy who make two blades of grass grow where one grew before, who raise social values, who make life worth living. They are humble and proud, they are strong and weak, they are rich and poor, but they all put honest effort into their work, they understand the ethics of a good job, and they cheat neither society, their employer nor themselves. Their final and ultimate reward is a consciousness of duty well-done and a recognition by their compeers. Without this intellectually dominating minority this world would be a poor place.

Now, if not all signs of the times deceive us, it will be this type of man in all classes of human activity that will decisively shape the future. For ourselves in our limited field we may say that this journal will continue to strive its best to act as a clearing house of chemical and metallurgical ideas, of chemical and metallurgical facts, of chemical and metallurgical figures so that the efficiency of chemical and metallurgical operations may be increasingly higher. Efficiency is the keynote of the coming transition period in industry, and as it is eminently sane, we cannot help looking with hearty optimism into the future and thus we extend to our readers the compliments of the season.

---

### Progress in Copper Metallurgy

As indicated in our previous annual reviews, the metallurgy of copper is now on such a basis that no striking innovations in smelting and allied processes have been made in recent years. In hydrometallurgy, however, the work of the past year leads us to suggest that we are on the eve of a remarkable development in this line. The success of experimental work already points to possibilities in reducing tailing losses and in making available vast quantities of copper-bearing material that hitherto have been untouched or regarded as waste.

In the preliminary preparation of copper ores by wet methods for concentration, the Hardinge conical mill, in an exhaustive test at Miami, proved itself superior to the Chilean mill in practically every particular and will be used generally in this class of work.

The handling of slime at Anaconda has been solved more satisfactorily than before, by means of Dorr thickeners and round tables. The round table is one of the oldest, but at the same time one of the most efficient machines for the concentration of extremely fine material. The objection to its use, however, has been its small capacity compared to the large amount of floor space required. A round table is usually from 20 to 30 ft. in diameter and has a capacity of about 6 tons of feed in 24 hours. By building tables with multiple decks, capacity per square foot of floor space is very greatly increased. Twenty-deck tables, with a daily capacity of 120 tons each are now in use, and tables with even 30 decks have been considered. Centrifugal concentration, which at one time appeared very promising, is abandoned temporarily at least, for these modified slime tables. Flotation methods, so generally used in the concentration of zinc ores, are slowly gaining ground for the treatment of copper ores.

The hydrometallurgical treatment of copper ores is rapidly advancing. About a dozen plants are now successfully treating copper ores or tailings by wet methods; and the number will almost certainly increase, for several companies are conducting experiments along this line. It is expected, for example, that an experimental plant for the treatment of copper slime by continuous counter-current decantation will be erected this year, making use of a principle which has been widely adopted in cyaniding slime. The mechanical thickeners for this plant will be constructed of acid-proof material.

The 80-ton hydrometallurgical plant of the Anaconda company is operating successfully and is the precursor of a much larger plant which will be erected to treat the daily tailing production as soon as a number of minor details are worked out in this commercial-experimental plant. The presence of silver renders necessary an oxidizing-chloridizing roast, and the results in silver and copper extraction and in cost of treatment have been very gratifying. Roasting is accomplished in modified MacDougal furnaces, having two fire boxes arranged so that their flames can be delivered to the third or fourth floor from the top. The third floor was finally adopted. The temperature is maintained at 1200° F. for oxidizing and at 1000° F. for chloridizing.

For complete roasting 3.56 per cent coal is required. Dust losses are small, ranging around 2 per cent. The recoverable percentages of silver and copper are 93.4 and 84.9, respectively. The cost for coal, acid and salt is estimated at $0.175, $0.096 and $0.07, respectively. The leaching solution contains 8 per cent. sulphuric acid and 10 per cent salt, and is used at a temperature of 85° C. The time required for extraction is about two and one-half hours. The total cost of treatment is estimated at 70 cents per ton, which makes the cost of producing copper from one-half per cent tailing seven cents per pound. The method of precipitating copper and silver from solution has not yet been finally adopted.

Two plants in Butte, the Butte & Duluth and the Bullwhacker, are operating on the oxidized surface ores of this district, using a sulphuric acid leach and electrolytic precipitation. The Butte & Duluth has recently changed its method of operation. Formerly the ore was crushed to ¼-in. mesh and leached in vats. Now, however, the ore is ground to about 8 or 10 mesh and slowly run through a series of very long Dorr classifiers, with counter-current washing in order to dissolve the copper and wash the solution from the ore. By this process the ore is exposed to acid for a shorter time, with less dissolution of such impurities as iron and aluminium, and with greater extraction of copper.

A modification of direct acid leaching is used at Braden, where a "neutralizing" leach with partly charged acid precedes the "acid" leach. Precipitation is electrolytic. At Chuquicamata the ore, mainly brochantite, is leached with dilute sulphuric acid and the solution is electrolyzed. In this case the acid accumulates in solution by additions from the ore itself.

The Bradley process, which has been tried at Anaconda for the treatment of slime, has not yet proved a commercial success, and the plant has been closed for several months.

At Great Falls, as a result of some very careful experimental work, the capacity of MacDougal roasters has been increased from 46 to 77 tons cupreous material per day, the sulphur in the calcines being 7.9 per cent and 8.9 per cent, respectively. With the increase in capacity there has been an accompanying decrease in the labor required. A resume of results shows 270 and 180 furnace men employed, under the old and new practice, respectively. The average number of furnace men employed per 100 tons of cupreous material was 1.52 and 0.93, and of feeders 0.59 and 0.44, respectively, under the old and new practice.

The sintering of copper ores has not made the progress accomplished with lead ores, mainly because of the fact that the need for such treatment is not nearly so necessary. Some isolated cases of sintering and agglomerating with slag have been noticed, but the practice has not been generally adopted.

The development in converting copper matte has been not only in the continued use of basic linings, but also in the adoption of much larger converters than were in general use in past years. Converters of the upright-cylinder type, 20 ft. in diameter, are being very generally adopted and tonnages of many thousands on a single lining are the order of the day.

The dismissal of the famous Anaconda smoke suit by the Supreme Court is the final chapter in this prolonged fight and spells peace at least in Montana. In California the appointment of a commission to pass upon the many phases of the smoke situation will tend to bring order out of the chaos which has existed in that state for so many years. In Utah the situation is not very different from that of the past five or six years.

The invention of William A. Hall, by means of which the sulphur of ores may be saved in the elemental state, is an epoch-making one, and if the promise made by experimental work is fulfilled, when applied on a commercial scale, the smoke problem may be considered solved. This invention is the more meritorious in that it brings to light reactions which hitherto have been apparently overlooked. We may expect that sulphur, the material which has caused so much trouble in the past, will soon become, instead of a menace, an actual source of profit to the copper smelter.

## Progress in Gold and Silver Metallurgy, 1913

Substantial improvement was made last year in methods of recovering gold and silver, but few striking innovations were brought forward. As has been the case in recent years, the cyanide process was the most important in point of quantity and value of metals recovered. Its use was extended to the treatment of a greater variety of ores; costs were reduced and extractions increased. Nothing of importance has occurred in the fields of amalgamation or smelting, and no data have been forthcoming from several attempts at chloridizing. The electro-cyanamide process, originally installed at the Ajax mill, Cripple Creek, was finally abandoned in favor of combined concentration and bromo-cyaniding.

A year ago we commented on the filter litigation and the successful defense of the Moore patents. At the same time we suggested that the end of the litigation was not yet in sight. The prediction was verified late in 1913, when Mr. Charles Butters filed a suit against the Golden Cycle Mining Company, Colorado, for damages for infringement of filter patents. This outcome was the more striking by reason of the fact that the Golden Cycle was one of the first to settle with the Moore company after the courts had sustained Moore's case against Butters. Mr. Butters has been active in other ways as well. In our department devoted to patents will be found a note on a new method of filter construction and operation, invented by Mr. Butters. His idea seems to be to avoid the Moore method of discharging the cake by a difference of pressure between the inside and outside of the filter leaf, and thus escape infringement of the Moore process. Another feature of the filter situation was the consolidation of the Oliver and Moore interests, possibly strengthening the position of both. On the other hand, the makers of the Portland filter, after investigating the whole matter of filter litigation, continued the manufacture and sale of their machines independently. While a number of large companies effected settlement with the Moore concern, many small users of vacuum filtration plants operated them without regard to the legal status of the business.

Consideration of the filter question naturally calls to mind the status of continuous counter-current decantation, as this process offers some measure of relief from the use of filters. Last year witnessed the greatest advances yet made in the use of this method of treating slime. Three companies abandoned filters in its favor: The Gold Road and Tom Reed, in Arizona, and the Lluvia de Oro, in Mexico; and a number of new plants adopted this method. The Gold Road company reports decreased loss both in dissolved and undissolved gold, partly due to further dissolution of metal in passing through the series of thickeners, although it was thought formerly that the plant had ample agitating capacity. Operating costs have been lowered. The quantity of cyanide used, covering both chemical consumption and mechanical loss, has been increased by not more than 1-10 pound per ton, although the ore is treated in a 2-pound solution.

At the Globe & Phoenix, Rhodesia, South Africa, a 350-ton continuous counter-current decantation plant was installed last year. Loss of dissolved gold in the tailing is reported to be only three cents per ton. A similar system was adopted by the Liberty Bell in Colorado, for the treatment of concentrates formerly sold to smelters. The new process affords a material saving to the company. In this case, in order to simplify treatment and reduce dissolved metal loss to a minimum, the tailings have been discharged into the regular mill circuit, ultimately passing out through the Moore filter. This gives the tailings additional agitation treatment and permits addition of all water at one place, *i. e.*, the filters. No additional labor has been required in the mill, and the total cyanide used is said not to be increased.

A late report from the Porcupine Crown mill, where the continuous counter-current decantation system was adopted, states that an extraction of 96 per cent is being obtained. This result is interesting in view of the fact that concentration is not practiced in this mill as in some others in the same district.

The tall form of air agitator for slime, commonly known as the Pachuca, seems to have fallen in the estimation of American metallurgists, for most of the new installations have made use of combination air-mechanical agitators, such as the Dorr and Trent. The former, first described in our issue last January, has been adopted in new mills in Nevada, Colorado, Canada and Mexico, and some older forms of agitators have been displaced in old plants by it. Experience with this form of agitator indicates low cost for power, continuity of operation and high mechanical efficiency. Sand and concentrates are readily handled, and the treatment is adapted to the chemical requirements of the ore, thereby giving high efficiency in dissolution.

The use of aluminium as a precipitant of gold and silver from cyanide solution received increased attention last year. This method is not new, having been proposed and patented in 1893 by Carl Moldenhauer; but the idea was never developed on a practical scale. Various experimenters have tried Moldenhauer's scheme, but it was not successfully used until Kirkpatrick developed the application of aluminium dust in 1908.

Dissatisfaction with zinc precipitation at the Nipissing mill, led to the investigation of the merits of aluminium, with the result that it was finally adopted. A study of conditions at this plant showed that precipitated solutions had lost their normal dissolving power, and the cause was finally attributed to the presence of zinc and arsenic in solution. Since the adoption of aluminium, no further difficulty of this sort has been experienced.

There are a number of advantages in using aluminium for precipitation. Although it is more expensive than zinc, yet much less of it is used per ounce of metal precipitated. Aluminium does not combine with alkali cyanide as does zinc, hence does not cause consumption of cyanide. When the precious metals are precipitated, all of the cyanide combined with them is regenerated. This necessitates the presence of free caustic alkali in the solution. One of the obstacles to the successful use of aluminium dust has been the difficulty of wetting it and getting a thorough contact with the solution. This is overcome by the use of some form of vortex mixer.

Another new proposal in precipitation made last year was that of MacArthur, who suggested the use of zinc wafers or small sheets. He reported very satisfactory results to the Chemical, Metallurgical and Mining Society of South Africa, but subsequent investigators in different parts of the world were unable to confirm his figures.

The old scheme of volatilizing gold and silver from sulphide ores by roasting with salt was revived last year as a new invention in Australia. As pointed out in our columns at the time, the process of volatilization had been exploited in this country over ten years ago, but for various reasons was not successful. The Australian venture also is said to have been dropped.

The development of low-grade gold mines in Alaska has resulted in plans for milling on a huge scale. At the Alaska Gastineau the development has been so rapid that each succeeding report of progress has far outdone its predecessor in reporting available ore, and the tonnage now in sight is beyond mental conception. Prospective mill capacities also have increased by leaps and bounds, and following the last visit of the promoters to the property the prospective mill capacity jumped from 6000 to 20,000 tons per day. But with ore now said to run into the hundreds of millions of tons, the present operators can project mills of almost any old capacity without depriving their descendants of an opportunity to work the property and derive some of the enormous aggregate profit now in prospect. Actual milling operations will be awaited with interest.

## Developments in the Metallurgy of Zinc in 1913

From a metallurgical point of view the status of spelter production was not materially changed during 1913. This is not to imply a dearth of experiment and research in the winning of zinc; on the contrary, there was marked activity in almost all branches of zinc-ore treatment. Some hopes have been realized, and progress has been recorded; but a reduction process has not been brought forth that can be considered a serious competitor of retort smelting.

In connection with retort smelting one item may be recorded which is of considerable advantage to the producer of zinc ore and concentrate. Hitherto the producers, particularly those whose output was small, have not benefited from any gold, silver, lead or copper which their products might contain, even though the gross value of these metals was substantial. In the case of large producers they might recover the retort residues and make a small profit by selling them to lead smelters, but such a procedure was out of the question for the small operator. More recently the zinc smelters have been offering contracts providing payment for gold, silver, lead and copper, in addition to the regular payment for zinc. The residues are then marketed by the zinc companies, and the small operator makes a profit without being put to the inconvenience of reselling small lots of residue.

This step on the part of the zinc smelters may be more or less of an experiment. Presumably it is not wholly philanthropic, and doubtless they anticipate a profit on the final transaction. The present forms of contract may be tentative, and the final form will depend on data accumulated from long experience; but the fact that other metals in zinc concentrates and ores are not to be a total loss to the producer is a matter for congratulation.

Electrolytic schemes for the reduction of zinc sulphate solution have been under close investigation during the past year. Metallurgically these processes look promising, but they seem to encounter serious economic obstacles. If we consider only the operating cost of production per pound of spelter, leaching and electrolytic reduction may show a margin of saving as compared with retort smelting; but if interest on investment and amortization of plant be included, the margin fades. This is due to the comparatively enormous cost of an electrolytic plant as compared with a retort smelter of equal capacity.

The situation with regard to electrolytic reduction in this country might be relieved if we had enormous zinc-ore deposits, so that a large tonnage could be relied upon for a long period of time. A company owning such a deposit might then erect an electrolytic plant with assurance that its cost would be distributed over a large tonnage of ore, and that the ultimate cost of spelter would not be unduly affected. But, as pointed out editorially a year ago, there are not many such deposits in the United States; our supply of zinc-ore comes from many small mines. Probably the last word has not been spoken on electrolytic spelter, and such processes will be investigated in the future; but under present economic conditions they do not constitute a serious menace to the continuance of retort smelting.

No less interest attaches to the development of electric zinc smelting. Experimental work has been unremitting and the results are encouraging. This branch of zinc metallurgy holds out hope for the direct treatment of both simple and complex ores, eliminating the present costly and wasteful intermediate processes of concentration and separation. Another attractive feature is the possibility of a high recovery of the precious metals which, in the case of a complex ore, are now subject to loss in a succession of processes. Direct smelting with electric power is probably nearer realization than it was a year ago, and there is a possibility that the coming year will witness an attempt to put it in practical operation.

The advocates of hydrometallurgical methods also have been active during the past year, and their processes have attracted the attention of spelter producers and mine operators. It was expected that chloridization would be in active operation before the year closed, but that achievement has been delayed for one reason or another, and we will have to wait for definite results of this process. Another hydrometallurgical scheme involves a sulphatizing roast with subsequent extraction in water assisted by acid treatment. The ultimate product is zinc oxide.

No definite work has been done in this country during the last year in the recovery of zinc from lead blast-furnace slags. One proposal, patented last year, suggests the treatment of such slag with lime to displace the zinc oxide, collecting the latter as it is driven off at a high temperature. The process would be applicable to molten slag as it comes from the furnace, thereby conserving much heat. Pyrometallurgical concentration of low-grade zinc sulphides and carbonates, producing crude zinc oxide for reduction to spelter, has not made further progress in this country, although the idea has not been lost sight of. The success of the Pape process in Germany, both on old slags and on crude ore, has attracted a great deal of attention, and it is not unreasonable to assume that it will soon be tried in this country. The need for some such scheme is becoming more urgent in view of the increasing quantity of finely divided concentrate produced by flotation methods. This concentrate is not desirable material for retort smelting. If it can be briquetted and converted successively into oxide and spelter, a problem now confronting the zinc smelters will be solved.

On the whole a commendable lot of work has been done toward improving present processes and in attempts to develop new ones. A great deal of time and money have been spent in investigation, and there is apparent willingness to test new ideas of merit. Apparently no line of development has been finally dropped, and the coming year should witness a nearer approach to the realization of the hopes and ambitions of different investigators.

### Developments in Concentration Methods

The record of ore concentration in the United States during 1913 is one of unusual interest. Technical literature has been replete with articles on research and practice, pointing the way to the solution of a number of problems and recording encouraging results from the treatment of ores that have been difficult to handle. Standard methods of concentration have held their own, but greater interest centers in the extension of accessory processes which must be credited with much of the improvement that has been shown in mineral recovery.

While a great deal of thought has been given to improved metallurgical efficiency, attention has been directed with increasing force to the economics of milling. Operators generally are realizing what the more thoughtful leaders have been emphasizing for some time, viz., that the highest metallurgical efficiency is not necessarily indicative of the most economic operation. In ore-dressing especially, commercial conditions must be kept in mind, and the requirements and preferences of the smelter must be considered. For obvious reasons smelter schedules favor the production of high-grade concentrates. Hence, one of the points the mill operator must keep in mind is the grade of his products. A high percentage of recovery in the form of a low grade product may not be as profitable as high-grade concentrate representing a lower saving.

Perhaps the feature that looms largest in last year's record of concentration is the wider adoption of flotation, not only for zinc but also for copper ores. This process unquestionably has made a place for itself and is accepted as a valuable addition to ore-dressing. The Minerals Separation process is in operation at two places in Colorado; it is being tested on a large scale by the Inspiration Copper Company in Arizona, and in a smaller way at numerous places in the Western states. The Butte & Superior Company, Montana, is using flotation on a large scale, treating zinc ore. The Minerals Separation Company claims an infringement of its process in this instance, and has already won a suit for damages. Pending an appeal by the defendant, the process continues in operation under an order of the court which requires Butte & Superior to make a strict accounting of all ore treated and concentrates produced by flotation. Regarding the outcome of this bit of litigation it would be hazardous to express an opinion, for past experience has shown that a legal opinion in such cases is not always consistent with sound technology. The result, however, undoubtedly will have a widespread effect on the future of flotation in this country.

In the mechanical concentration of slime no striking innovations have come forth. Multiple-deck tilting tables have found some advocates, and various forms of vanners have continued in favor. In a notable case, however, that of the Anaconda Copper Company, the buddle has found preference after a long campaign of costly experiment with various forms of slime concentrators. Twenty-deck buddles are a novelty, but they seem to be a rational development for the concentration of slime on a huge scale, and will be used at Anaconda this year. More extended reference to these machines will be found in our editorial review of copper metallurgy.

Another development at Anaconda, resulting from exhaustive tests, was the adoption of the Dorr continuous slime thickener for preparing suitable feed for the buddles. This device, well known in cyaniding, is finding extended use in concentration as a means of securing a feed of uniform consistency for flotation boxes and mechanical slime concentrators. The Anaconda installation consists of 40 four-deck Dorr thickeners, handling 20,000,000 gallons per day of water containing 2000 tons of slime. Other installations of thickeners in concentrating mills have been made by the Nevada Consolidated, Montezuma and Old Dominion copper companies. Scattered installations of these machines in flotation plants have proved valuable in preparing feed and in recovering water from tailings.

Dry concentration and separation has had an encouraging year. An elaborate testing and custom plant was erected in Denver by the Sutton, Steele & Steele Company for the demonstration of dry tables and dielectric separators. Many tests have been made and some custom work done on large lots. No new plants of this kind have been erected, but several are in prospect and may be built this year. One of the new machines brought out by this company, and now practically perfected, is an electrostatic table, being a reciprocating deck with an electrically charged surface over which the mineral particles progress by a series of jumps.

One of the most interesting and promising developments of the year was the Plumb pneumatic jig, described fully in our last issue. The features of this machine are simplicity of construction and operation, and perfect automatic control in discharge of concentrate and tailing. It offers an advantage in producing unusually high-grade concentrates, and has already attracted the favorable attention of some large operators. The coming year should witness its adoption in commercial work.

Electrostatic separation has been more widely adopted in the treatment of zinc-iron ores. Being a process of limited application, it is not in general use; but in those cases to which it is adapted, it is giving excellent results. The Huff machine has been greatly simplified in the manner of construction so that troubles incident to electrodes are believed to have been largely overcome. A good example of the conditions under which electrostatic separation is valuable will be found in the work at the Mary Murphy mill, described elsewhere in this issue.

In the preparation of ores for concentration, some new work has been done in sizing machines. Promoters of dry processes realize the necessity of reasonably close sizing, and have been trying to avoid the use of screens. Development work on the McKesson-Rice screenless sizer has been continued, and the Sutton, Steele & Steele Company has a new device for a similar purpose. Classification for wet ore-dressing has been improved and extended, although efforts are still being made to produce concentrators that will treat an unclassified feed. The new Isbell table is said to do such work with fair success. On the other hand, Prof. Robert H. Richards, always a strong advocate of classification, has recommended even greater refinements in the preparation of table feed; and, in a paper presented to the American Institute of Mining Engineers, has shown the probable benefits to be derived therefrom.

---

## Showing of the Iron Industry in 1913

Market developments of the past year, studied in the retrospect, furnish ground for some interesting conclusions. Of greatest importance, perhaps, is the fact that while general trade activity began to decrease early in the year, it was not until the beginning of October that steel mills began to operate at much less than their full capacity. Several months before that decrease occurred the mills themselves had begun to look for a decided recession in demand and there is little doubt that the majority of producers were really surprised at the way material was taken in June, July, August, and September. The unexpected usually occurs in steel, and so it was that while one would normally expect an improvement in business in the early autumn it was just at that time that the real decrease in consumptive demand began to show itself.

Steel mill operations made a wonderfully good showing in the first nine months of 1913, viewed from the standpoint of business conditions generally, and this fact may indicate something. Upon analysis, it does not appear that in any specific direction there was a particularly heavy demand. There was no great rush of public or semi-public improvements. The railroads were moderate rather than heavy buyers. The steel flowed out through a multitude of channels. The consumption of steel has very greatly broadened in the past half dozen years, and this fact can be realized by recalling the nature of demand in 1906, which was a remarkably good year. Then there was extremely heavy buying by railroads; rail production reached a total which has not since been attained, even though the total production of steel has since greatly increased. The railroads were also heavy buyers of cars, locomotives and bridge material. Many large structures, office buildings, hotels and bridges, were erected, consuming a larger percentage of the total output than is the case to-day. The tin plate production of the year, on the other hand, was 576,079 tons, whereas in 1912 and 1913 it has been about a million tons. There has been a correspondingly great increase in the production of sheets. The steel needed for the ordinary activities of the people has greatly increased, while there has not been as great an increase in the consumption of steel in the large channels, where financing is usually necessary. It has been relatively difficult to finance large projects in recent years.

These considerations furnish a basis for constructing a theory that the steel industry is undersized for the normal consumptive requirements of the country. It is not reasonable to conclude that the requirements of the ordinary people will not continue to increase, while it is hardly unfair to assume that a time is coming when large projects can be more readily financed. On any other basis it is difficult to explain why the steel industry reached a stage of full activity so readily in 1912, or why it continued its full activity so long in 1913.

A year ago, in reviewing the developments of 1912, the curious position of the merchant furnaces was referred to. It was pointed out that the year had brought an advance of about $4 a ton in pig iron, from a level which was absolutely profitless to the majority of merchant furnaces, but that three-fourths of the pig iron advance had been absorbed by advances in ore and coke, which many of the merchant furnaces must buy. The market did not seem to be giving the merchant furnaces their just due. It has all come out in the wash. There is too much merchant furnace capacity. A condition in general trade which easily gave full employment to the steel works, now supplied with pig iron almost wholly by their own blast furnaces, did not give full employment to the merchant furnaces. There has not been a sufficient increase in the pig iron requirements of foundries, malleable, gray iron and steel, to balance the increase in blast furnace capacity. Steel works have built furnaces so as to avoid buying merchant iron, and Lake Superior iron ore interests have built merchant furnaces so that they could consume their ore instead of selling it to merchant furnaces.

Largely as a result of this difference in alignment of the steel and merchant blast furnace industries to their respective markets, pig iron prices began to decline at the beginning of 1913, whereas steel products did not begin to decline measurably until August. Present pig iron prices represent a profitless level to a great many merchant producers, while the same statement cannot be made of steel products.

Despite the unfavorable trend of affairs, the year 1913 established new records throughout the iron and steel industry. Pig iron production amounted to about 31,100,000 tons, against 29,726,937 tons in 1912, which in its time was easily a record year. The production of steel ingots and castings was between 32,500,000 and 33,000,000 tons, against 31,251,303 tons in 1912. The production of rolled iron and steel was close to 26,000,000 tons, against 24,656,841 tons in 1912. Lake Superior iron ore shipments were about 49,750,000 tons, against 48,211,778 tons in 1912. The gains in production over 1912 were all effected in the first half of 1913; the second half developed production approximately at the average rate of 1912.

There is speculation as to the cause of the slump in demand which overtook the industry in the closing months of the year. Explanations drawn from recent precedents, 1907 and 1910, are quite insufficient, particularly if it be held that the present decreased demand is to continue as was the case after the recessions cited. In 1907 there was a financial panic, the unsoundness which thus culminated having been apparent for months in that no new projects of any magnitude were undertaken. Towards the close of that year practically all large work on hand was suddenly completed, bridges, buildings, railroad extensions, etc., whereas there has not been a great deal of large work in the past year, and much of the work that was in progress has not been completed. Two of the biggest jobs in steel ever undertaken, the Hell Gate bridge and approaches and the New York subway work, still involve years rather than months of work.

The decrease in demand in 1910, the latest precedent, was clearly seen later to have been due to the fact that the country stocked up with material, bought on the 1909 break in prices, the encouragement to stock up being furnished by the spectacular advance which occurred in steel prices during the second half of 1909. The stocks had to be liquidated, and the liquidation was not completed until 1911. In the past year there has been no similar stocking up; stocks are admittedly low everywhere.

Two hypotheses remain: that there is a period of decidedly bad business in store for industry in general, which would necessarily keep the steel industry from regaining a state of full operation; or that the present decreased demand for steel will prove only temporary.

The feeling so prevalent in many quarters that business is going to be bad for some time appears to come from psychological rather than physical causes. Many are disappointed that we have a Democratic administration, are disposed to be critical, and refuse to take anything on faith. But the tariff shows no signs of hurting the iron and steel industry, for October, the first month of the new tariff, showed absolutely negligible imports. The October trade balance in general, by the way, was spectacularly large, breaking all records for a month, and although not aided by harvest movement was at the rate of $1,670,000,000 a year, a rate of a billion dollars in excess of the best trade balance ever shown for a year.

If the present decreased demand for steel is only temporary, it can readily be explained. There is always, between buying movement in steel, a period of reaction during which prices fall, buyers restrict their purchases and reduce their stocks to the absolute minimum. Once it is established that a bottom has been reached, whether the period required be long or short, the market quickly revives.

# Readers' Views and Comments

## Microstructure of Raw and Manufactured Copper

*To the Editor of Metallurgical & Chemical Engineering:*

Sir:—In your November issue (p. 621) in the report of a meeting of the New York Section of the American Electrochemical Society reference is made to a paper on the "Microstructure of Raw and Manufactured Copper" by Mr. W. H. Bassett, Technical Superintendent and Metallurgist of the American Brass Company. A note is made of the structural changes in copper due to working.

Some six or seven years ago, whilst engaged in electrolytic refining of copper, occasion arose to discard several lengths of conductor bars. These had a sectional area of about 4 sq. in. The smiths on the plant could not work up or draw the old leads to make use of them for other purposes. These leads were all made on the works from electrolytic copper of 99.95 per cent copper content and having conductivity varying between 100 and 101 Matthiesen standard.

Little use was made of microphotographs at that date for determining impurities in metals. Through the medium of your columns I should like to ask if Mr. Bassett has ever applied microphotography to determine whether any structural change has taken place in a conductor carrying for a period of five years, a current such as is used in copper refining.

Can any one say why such copper bars could not be worked or drawn and had always to be sent to the refining furnace to be melted.

It would be of interest also to know if any change takes place after long use of conductors carrying high voltage currents from central power stations.

*Gourock, Scotland.*

Harry A. B. Motherwell.

* * *

## "Hydrometallurgy—Joys of Its Theory, Woes of Its Practice"

*To the Editor of Metallurgical & Chemical Engineering:*

Sir:—Referring to Mr. Malm's communication regarding chlorination of ores, I wish to mention some general points which occur to me. There is only a difference of opinion between Mr. Malm and myself as to whether this process will serve a useful purpose in producing metals cheaper than they are now produced in well-known and simple processes. All of Mr. Malm's figures for operations of this kind are based upon assumption.

Mr. Malm's process will serve a useful purpose, in my judgment, only on finely disseminated ores which are not mechanically separable. When he tries his scheme (demanding highly refined operative work) on a large daily tonnage scale, against good mechanical separation schemes, it is my opinion that he will not find the wide margin of profit he mentions in anticipation.

There are only a few mines producing complex ores of such a nature, or in such a finely disseminated state, that they cannot be separated with good milling practice. Separation processes are not usually applied at the best efficiency, because the miner, millman or mining engineer usually is not a first-class metallurgist. Consequently when one decries the failure of separation processes in such hands as these, he is not treating the possibilities fairly. And I venture to say that if some of the new complex, hydrometallurgical schemes were used by the average operator the results would be far inferior to those now obtained by mechanical processes.

There is no question in my mind that we are passing through a period of refinement in mechanical separation processes, and that these improvements will put such processes in the running with any complex chemical procedure that demands fine chemical balancing and control.

It is with regard to the comparative cost of old, proved processes, properly operated, and an estimate of the cost of his process that Mr. Malm and I cannot agree. For a long period of years it has been my privilege to compare anticipated costs with actual book costs in working chemical and metallurgical processes. One of the most difficult things that I have to contend with, and one that I find many others will not contend with, is to add enough to the proposed cost of a process to make the venture safe from a pocketbook point of view; and one of the most deplorable things is the attempted estimation of costs by persons who are inexperienced in such matters.

Just at the present time, for instance, an engineer of wide metallurgical training is working on an acid-leaching process, and has published figures on making sulphuric acid that are just about one-half what anyone else in the United States has been able to make it for; and, at that, under conditions of labor, supplies, etc., that are not as favorable as those existing at plants now in operation. I know how prone one is to under-estimate rather than over-estimate costs; and I know how process promoters err on this more than would an operating engineer.

I understand that Dr. Chauvenet's contention is that, no doubt, the costs of dry chlorination are underestimated at several points; and that, since financial profit determines the value of any process, the one in question is not considered good. In this connection I agree with Dr. Chauvenet and not with Mr. Malm.

Finally, I would like to refute the impression that has gone abroad that metallurgists engaged, for instance, in the zinc business, are asleep at the switch; that they are not competent to judge the value of various newly proposed schemes; that they want to stick to a cumbersome, annoying process rather than accept one that can be worked with regularity and ease. It is ridiculous to assume that our operating metallurgists are passing all the good things by.

*Denver, Colo.* Lewis B. Skinner.

* * *

*To the Editor of Metallurgical & Chemical Engineering:*

Sir:—My discussion of hydrometallurgy, in reply to Dr. Chauvenet's article, was not intended to embrace an adverse criticism of the Malm process. The presence of a single impurity ought not to be fatal to the operation of an otherwise successful process. Further, it was my understanding that the Malm process, although advertised for a number of years, had never been put into actual commercial operation. Mr. Malm has now specifically stated this to be a fact, thus giving sufficient authority for my statement that the theory is the best part of the process.

However, since Mr. Malm has frankly suggested that I am ignorant of the subject, simply because I mentioned it incidentally, and further since he insists upon a statement from me relative to his process, I am forced to proceed with a criticism of the Malm process in greater detail.

I wish to point out the following things: (1) My understanding of the theory of the Malm process; (2) the fact that the Malm process is inoperative; (3) that the data given are incorrect and absurd; (4) my reference to the Malm process was justified by published facts.

Finally, Mr. Malm had knowledge of the paper and articles to be mentioned below, and if they were not in accordance with his results a public denial should have been made at the time. Further, the authorities quoted show such an intimate knowledge of the process, the equipment, the analyses, recovery and cost, that it is hard to believe that they were not inspired by Mr. Malm himself.

At a regular meeting of the Western Association of Technical Chemists and Metallurgists, held in Boulder, Colorado, January 4th, 1909, the Malm process was described by Dr. F. W. Traphagen, professor of metallurgy in the Colorado School of Mines.

The Malm process was specifically described in the Western Chemist and Metallurgist, in the May number, 1910, by Mr. Harry J. Wolf. The Malm process was again specifically described in the Western Chemist and Metallurgist, June, 1910, by Messrs. Jean McCallum and E. J. Bruderlin, of the Colorado School of Mines.

Details of this process after this time, so far as I have been able to ascertain, are meagre.

In case the process described in the references is not the Malm process, the matter is between Mr. Malm and the authors.

Quoting from Mr. Wolf: "In the Malm Process, or Western Metals Process, as it is sometimes called, the ore is suitably crushed, dried and subjected to the action of chlorine gas. The metals are converted into chlorides, which are dissolved and separated by methods of substitution. The zinc chloride is dissociated in an electrolytic cell of special design and the chlorine gas is recovered for reuse. The process is described more in detail as follows:"

Further: "The properly prepared ore is fed to a revolving tube of special design, in which it is subjected to the action of chlorine gas. The pulp is kept in contact with the gas long enough to chloridize 40 per cent to 70 per cent of its metal contents. The reaction between the gas and the sulphides is exothermic."

Further: "When the chloridization in the tube has been carried far enough to suit the requirements of the particular ore under treatment, the partially chloridized ore is passed from the tube into an agitator tank, where it is agitated in water or mill solutions, in the presence of free chlorine gas. Extraction is thereby completed and all the metal chlorides pass into solution."

A beautiful process of substitution is then described, the gold and silver being precipitated with metallic copper, the copper precipitated with metallic iron, the iron and manganese are reoxidized with chlorine gas and precipitated with zinc oxide, the calcium chloride is converted into calcium sulphate with zinc oxide in the presence of sulphur dioxide, and finally the solution is evaporated to dryness and the zinc recovered by fusion and electrolysis.

The molten zinc is recovered, and the chlorine is peacefully led back to the tube mill.

Thus we have a complete cycle of reactions which delight the soul of the professor and student alike. The chemistry is perfection itself; the chlorides without exception have a much higher heat of formation than the corresponding sulphide, and the substitution process dovetails like a set of child's blocks.

This is my understanding of the Malm process.

The Malm process will not decompose minerals other than sulphides, since the oxides, carbonates and silicates have higher heats of formation than the respective chlorides. Naturally some of the chlorine will in one way or another decompose a small quantity of water, forming hydrochloric acid, and some of the sulphur will be oxidized to sulphuric acid, but the action of these acids is not contemplated in the process as described.

Assuming that the most favorable conditions can be maintained, the extraction as claimed is difficult. Those who have worked with large quantities of chlorine gas and solutions containing chlorine will appreciate that the difficulties are almost insurmountable. There are but few containers adapted to mill work which will easily hold solutions strong in chlorine and at the same time permit the necessary agitation. Also one would not have an unlimited choice of filtering media. It is well enough to say that a filter press of suitable design may be used, but it is a more difficult thing to tell what the suitable material is. This applies to tanks and agitators as well.

The substitution reactions are not quantitative in a commercial way. It is always necessary to have an excess of precipitant in solution. For example, take barium sulphate, one of the most insoluble compounds met with in ordinary work. Try to precipitate all of the barium out of a solution with the theoretical quantity of sulphuric acid. It takes 24 hours for this reaction to take place completely, and then under favorable conditions of excess and temperature.

Assuming one has sufficient tank capacity to hold a thousand pounds of lead chloride in solution, the precipitation of the lead completely with metallic zinc will take time and more time. Also the zinc is going into solution at a very rapid rate, regardless of the lead.

Consider the laboratory precipitation of iron with zinc oxide. The conditions must be delicately adjusted, and a large excess of the precipitant must be added.

There is no magic in large operations which changes these things fundamentally. Time, concentration, heat, and equilibrium must be taken into account in the mill as well as in the laboratory.

Given unlimited time, unlimited apparatus, ideal materials, all of the reactions will take place, each in its turn and according to the chemical laws governing each case. It has yet to be demonstrated that the reactions as claimed will take place in an ordinary plant where operations are continuous and concurrent, where ordinary human beings are a function of operation, and where expensive and fragile apparatus must be used in handling large quantities of very low grade solutions and pulps.

The mainspring of the entire system, the electrolytic decomposition of zinc chloride is in itself a delicate operation. If the production of zinc were as easy as one might be led to believe from a description of this process, no other known process for the recovery of this unhappy element could compete with the electrolytic process. The ease with which zinc is obtained in the Malm process will be referred to later.

I probably shall not convince Mr. Malm that the process is inoperative, but I have stated my reasons specifically above.

To quote further from Mr. Wolf: "From 60 to 70 per cent of the cost of operating this process is for electric power. Direct current at relatively low pressure is used for the electrolytic work. The consumption of power varies with the metal contents of the ore. In practice an actual recovery has been made of 14.2 to 14.4 pounds of zinc per horse-power day."

The theoretical quantity of zinc deposited per horse-power day at 3.5 volts (the voltage specifically stated) is:

$$\frac{746 \times 24 \times 3600 \times 32.7}{3.5 \times 96{,}540 \times 453.5} = 13.8$$

The electrical efficiency of the process is therefore

$$\frac{14.3}{13.8} = 103.5 \text{ per cent.}$$

The heat required for the operation is doubtless derived from the calcium sulphate.

The recovery is stated to be as follows:

| | |
|---|---|
| Gold | 90 % |
| Silver | 91.6% |
| Lead | 97.4% |
| Copper | 99.3% |
| Zinc | 94.2% |

The value of the above products taken from one ton of ore is said to be $23.58. The total cost, including mining, freight, selling and overhead charges, as well as a royalty of 85 cents per ton, is given as $13.57, of which the "entire cost of treatment" per ton is $5.32.

On the average, 65 per cent of this $5.32 was for current; or the entire cost of grinding, chloridizing, decanting, heating, filtering, drying and bottling was $1.86 per ton.

It will be noted that for every pound of metal recovered, at least one pound of zinc must be plated out. To be conservative one should say a pound and a half of zinc to allow for an excess of the precipitant in each case. If this is true (it is an assumption on my part, and not a statement of the writers referred to) we see 414 pounds of zinc recovered per ton of ore treated at a cost for electrical energy of $3.46. One may be sure that there is no half-cent-per-kilowatt-hour rate in Colorado. It is nearer two cents.

This freak list is not complete without the analysis of the ore. The crude ore assayed as follows:

| | |
|---|---|
| Gold | 0.18 oz. per ton |
| Silver | 13.97 " " " |
| Lead | 4.78% |
| Copper | 0.68% |
| Zinc | 9.00% |

It is a remarkable ore which can be obtained for treatment in quantities of 15 tons per day and contains no silica, lime, iron, magnesia or arsenic. These should have been mentioned, since every pound of iron and lime which are chloridized must be disposed of at a heavy expense of zinc.

It is stated that the average profit per ton was $10.00. This means nothing short of $150 per day, or $45,000 per year of 300 days. This is 10 per cent net income or close to half a million dollars. Half a million dollars would put up a fair-sized plant, so Mr. Malm has only himself to blame if he is still unable to complete his Georgetown mill.

Therefore I am convinced that the statements in the references are both incorrect and absurd.

As to the calcium sulphate proposition, it was stated at the meeting above mentioned that the calcium sulphate was causing considerable difficulty. It is stated in one of the articles that calcium sulphate is precipitated by zinc oxide and sulphur dioxide. It is a matter of common knowledge that mill solutions retain relatively large quantities of calcium sulphate, and upon evaporating these solutions the material will certainly appear in the residue.

It now appears that Mr. Malm has either greatly modified his process or developed an entirely new one. Of this I freely confess to know but little. It is to be hoped that this new process will come from under cover so that it may be intelligently discussed, if Mr. Malm desires such a procedure. I do not believe there is a metallurgist in the world who would not be pleased at the ultimate success of the dry chlorination project; and Mr. Malm is deserving of great praise, and substantial reward, should he succeed in making his dream come true. The problems to be solved are as numerous as they are formidable. That many of them have been overcome I believe.

Until such a time as Mr. Malm gives us an equally detailed statement of his present process his previous utterances should stand, and we must base our opinions upon the information he has given us. It remains for Mr. Malm to state specifically and sincerely how he can recover the values from complex Colorado ores at the exceptionally low figure of two and one-half cents per pound.

Warren F. Bleecker.

*Canonsburg, Pa.*

## The Western Metallurgical Field

### Gold Mining and Milling in Georgia

Those who have investigated the history of gold mining in America are inclined to believe that the origin of the industry can be traced to early discoveries and operations in the southern Appalachians. In any event, gold has been produced in Georgia since 1829, for which year the output was officially noticed in the U. S. Mint returns. In 1838 the government opened a mint at Dahlonega and continued coinage there until 1861. This mint coined over $6,000,000 in gold.

At the December meeting of the Colorado Scientific Society, Mr. A. J. Hoskin presented the results of his experience with gold mining and milling in Georgia, giving many details of historical discoveries and early operations, and reviewing the present status of the industry. The rock formations containing the valuable ore deposits are all metamorphosed. The original sedimentaries were chiefly sandstones and slates; but oxidation has been constant, and the original rocks have decomposed in place, giving rise to a condition peculiar to this region, and affecting the methods of mining and milling. The term "saprolite" (rotten rock) has been coined to describe the ore. It is soft and friable, and disintegrates readily in water.

The fineness or purity of Georgia gold is very high, varying from 950 to 980, being wholly free from copper and alloyed with silver only. In size the gold ranges from dust to large nuggets. The small particles of gold are difficult to recover in milling, as they do not readily amalagamate. Some of the difficulty in amalgamation is attributed to nature of the gangue rather than to the quality of the metal.

The mining methods adopted are peculiar to the region, and consist generally in hydraulicking or in dry pick-and-shovel work with subsequent sluicing of the loosened mass from the open cut. The milling process would be deemed inefficient in comparison with practice in the West. Too many opportunities exist for loss of gold. The first part of the process consists in what is known locally as "reducing," meaning thereby a decrease or reduction in the bulk of the ore sent to the mill. This is accomplished by sluicing the ore from the open cut to the mill. During its travel through the sluice the ore is disintegrated, so that on arriving at the stamp mill much of the material will pass a screen of ½-in. or ¼-in. mesh. The Georgian miner assumes that only the coarse portion is worth treatment by amalgamation in the mill, for the gold in the disintegrated portion is supposed to have been recovered in the sluice. Hence the portion passing the screen is run to waste. It would seem almost certain that much gold must be lost in the fine particles that pass the screen, but such is the custom of the local miner; he recovers some gold in sluices, being that part of the metal which has been liberated by the disintegration of the ore, and then treats the coarse ore by stamp-amalgamation to make an additional recovery.

The stamp mills have been evolved to suit local conditions. The stamps are light, weighing from 300 to 450 pounds each. They are run with a low drop, about 95 per minute, and are fed by hand. The plates are silvered copper, but owing to the poor treatment given the plates by the millmen the results are not all that could be desired. The plates are kept too hard or dry, and the millman apparently is averse to using enough mercury to give a proper surface for good amalgamation. This makes cleaning-up a difficult matter, and consequently leads to another bad practice, viz., the use of sharp putty knives in scraping the plates. Knives have always been used to detach the dense deposits from the plates—a practice which might be tolerated with cheap copper plates, but which is prohibitive with expensive silvered plates.

Sulphide ores are found in Georgia, but the miner has a strong aversion to them on account of the fact that they blacken the plates. Mr. Hoskin found that the cause of this lies in the extreme acidity of the ore. Not only does the sulphuric acid foul copper plates, but it rapidly destroys silvered plates.

The general grade of Georgian gold ore is low, averaging about $2 per ton. Extraction percentage is low, being about 50 per cent.; but even with the low-grade ore and low extraction, a profit can be made, owing largely to the cheapness of operation. The Georgia gold fields are nearly dormant at the present time, but are beginning to attract the attention of modern metallurgists, and there is a growing belief that greater activity will be seen within the next few years.

### Concentration of Old Tailings

A novel milling proposition has been undertaken in Colorado by Messrs. Otto Mears and A. R. Wilfley, having for its object the recovery of tailings from a mountain lake and their reconcentration. The Silver Lake mine at Silverton, Colorado, is one of the famous properties of the San Juan region. Like most San Juan mines, the Silver Lake is high in the mountains, being at an altitude of over 13,000 feet. The first mill erected for the concentration of the ore was located at the mine, and discharged its tailings into Silver Lake. The quantity of the material thus accumulated is estimated at about 500,000 tons. This was before the advent of the modern concentrating machinery, and the tailings are probably much richer than would be tolerated under modern conditions.

Some time ago the gentlemen above mentioned projected a plan for the recovery and reconcentration of these tailings, and ultimately began work on a plan which is expected to yield a considerable profit. The tailings are to be pumped from the lake bed and flumed a distance of several miles, being finally delivered at a new mill erected on the Animas river, at an altitude of about 9000 feet. In the new plant there will be concentrating machinery adapted to the treatment of the material. Wilfley multiple-deck tilting slime concentrators will be a feature of the equipment. The capacity of the plant will be over 500 tons per day. It is expected that the average value of the mill feed will be $3 per ton, and a profit of over $1 per ton is anticipated. Owing to the severity of the winter season in the San Juan, it will be possible to operate this new tailings mill only in the summer.

### International Engineering Congress

One of the features of the Panama-Pacific International Exposition in San Francisco, in 1915, will be an International Engineering Congress, embracing all branches of the engineering profession. The date has been set for the week of September 20-25, 1915, which probably is far enough in the future to enable all interested engineers to lay their plans to attend. It is the purpose and object of the congress to gather together engineers from all civilized countries, and offer opportunities for professional and social intercourse. The reading and discussion of papers will be an important feature of the meetings, and the publication of these papers and discussions in suitable volumes will form a permanent record of the transactions. A tentative division of the general engineering field into eleven sections, and the proposed publication of ten volumes of papers, one for each important division, form part of the preliminary arrangements now under way. Of special interest to our readers are the sections devoted to mining engineering and metallurgy, electrical engineering and mechanical engineering. The fee for general membership, including a single volume of transactions will be $5. The committee of management is now seeking to get in touch with all engineers who may be interested, and further information can be obtained by communicating with the secretary, W. A. Cattell, Foxcroft Bldg., San Francisco, Cal.

### New Copper Smelter for Arizona

The International S. & R. Co., now operating a copper and lead smelter at Tooele, Utah, has commenced construction of a new copper smelter near Miami, Ariz. This plant is being erected for the treatment of the concentrates that will soon be forthcoming from the new mill of the Inspiration Company. It is not unlikely, also, that an arrangement will be made whereby the concentrates of the Miami mill, now being sent under contract to Cananea, Mexico, will ultimately be treated by the new smelter. The plant will consist of three modern reverberatory furnaces, possibly one blast furnace and a complement of converters. Considering the immense amount of construction work now under way on copper mills and smelters in Arizona, the addition of a new plant will make this state the most active among Western copper producing states. Needless to say the new plant will be a model of its kind, and unsurpassed by any in the country.

### Company Reports

The fifth annual report of **Stratton's Independence, Ltd.**, has just been issued, covering operations to June 30, 1913. During the period under review the mill treated 104,111 tons of dump ore and 25,999 tons of mine ore, totaling 130,110 tons. The average grade of the ore was 0.1538 oz. gold per ton. The total gold content of ore treated was 20,013 oz. gold, and the recovery was 15,707 oz., or 78.48 per cent. The recovery in concentrates was 34.43 per cent. and in cyanide bullion 44.05 per cent. The percentage extraction is higher than for several years previous. The percentages of recovery from concentrates and bullion are practically reversed from those reported for previous years. Two grades of concentrates are produced; the first grade averaged 4.118 oz. gold per ton, and the second 1.847 oz. All concentrates were sold to smelters. The cost of milling was $1.32 per ton, divided as follows: Coarse crushing and sorting, 17 cents per ton; fine crushing, concentrating and treating concentrate, 52 cents; cyaniding and special chemicals, 50 cents; miscellaneous, 13 cents. The cost of mining dump ore was 12 cents per ton, making a total cost of $1.44 per ton. The average tonnage milled for the fiscal year was 10,842 tons per month. The managers of the property expect to improve results this year.

The **Messina (Transvaal) Development Co., Ltd.**, operating copper mines and reduction works in South Africa, has issued a report for the quarter ended September 30, 1913. This company is one on which Camp Bird, Ltd., holds option for a large number of shares. The first reverberatory smelting furnace was started last July and the second furnace in August. A small calcining furnace was completed and started in September. Two additional reverberatory furnaces are to be added to the equipment and a mechanical roasting furnace also will be built. The report shows that during the quarter the mill produced 1207 tons of 44 per cent. copper concentrates and 918 tons of 8 per cent. middlings. The smelting plant produced during the two months of operation in the quarter 134 tons of 50 per cent. copper matte. This company is just coming into the producing stage after twelve years of development work. A railroad is practically completed to the property and operations are expected to go forward much faster from this time on.

## The Iron and Steel Market

At the close of December a slight improvement is noticeable in the general tone of the iron and steel markets. By the close of November the curve of descending prices in both pig-iron and steel products was trending around to the horizontal and during December the trend has been still more marked. The concavity of the curve is clearly discernible and while this fact is not conclusive as to the future course of the market it is at least a strong indication, for iron and steel prices generally move in great swings.

Prices are not as low, by about 50 cents a ton in pig iron and about $2 a ton in unfinished and finished steel, as they were two years ago when the market made its great descent, to the lowest level since 1904 in pig iron and the lowest level in finished steel since the early part of 1899. It is claimed, however, that the cost of production has meanwhile increased, and that furthermore producers are firmly set against permitting the market to reach a profitless level. Curiously enough, the reduction in the tariff is mentioned as one cause of this resistance to declines. It is suggested that in the past producers were able to average high and low prices, but since the reduced tariff now precludes high prices being attained, sellers must be careful not to allow very low prices to be attained at all. Probably there is something in the argument, for with the chance of importing material before then, it would be more difficult to stampede buyers into purchasing on a rising market.

In the fore part of December steel mills operations were at about the same rate as at the close of November, about 50 per cent of full capacity, but with extensive closing of plants over the holidays the month's production and shipments have probably not been much above 40 per cent of capacity. There is clear prospect of heavier tonnage in January, this probably to be followed by continued improvement in following months.

Despite the unfavorable sentiment that has been so prevalent, close analysis fails to disclose anything radically wrong with the country. Thus far the tariff reduction has shown itself far less dangerous than was predicted. October, the first month of the new tariff, which became law on the night of October 3, showed inconsequential iron and steel imports, practically no increase over August and September, and a great reduction as compared with the earlier months of the year, while the country's general balance of trade was the greatest for any month in history. The currency question is settled and criticism of the new arrangement is likely to subside. The trust question is next in order for discussion at Washington, and the discussion can hardly prove as disturbing an element as has been the uncertainty of business men as to what they could do and what they could not do. In nearly all quarters it has been agreed that settlement in almost any fashion would be better than the uncertainty.

### Pig Iron

The market was a dull and dragging one in the fore part of December, but just after the middle of the month it developed that two important interests, the International Harvester Company and the American Steel Foundries, had made important purchases, involving 50,000 to 75,000 tons, for forward delivery, this constituting the first forward business of any magnitude closed since midsummer, and it is not improbable that after the turn of the year the pig iron markets will feel some stimulus in consequence. Prices are very low and production appears to have been restricted to the full extent required by reduced consumption, if indeed the restriction has not gone too far. Declines since last report have been light. Quotations are: No. 2 foundry, f.o.b. Birmingham, $10.50 to $11; No. 2 X foundry, delivered, Philadelphia, $15 to $15.25; No. 2 X, f.o.b. Buffalo furnaces, $12.75 to $13; No. 2 foundry, delivered, Cleveland, $13.50; No. 2 foundry, f.o.b. Chicago furnaces, $14; at Valley furnaces (90 cents higher delivered Pittsburgh), Bessemer, $15; basic, $12.75; malleable, $13.50; No. 2 foundry, $13.50; forge, $13.15. Ferromanganese was reduced $3 a ton early in December and is quotable at $47, f.o.b. Baltimore, for English or German, prompt or forward.

### Steel

December settlements of prices on monthly adjustment contracts were on the basis of $20 for billets and $21 for sheet bars, at maker's mill, Pittsburgh or Youngstown. In some instances slight concessions are understood to have been made, but these figures closely represent the quotable market. Rods have softened to $25.50, Pittsburgh. The market is stronger in tone in that mills refuse to sell billets or sheet bars for second quarter at prevailing prices, and even for first quarter are not always willing to sell Bessemer at the same level as open-hearth. They claim the production cost is higher for Bessemer. Frequently open-hearth steel has commanded a premium over Bessemer, and the relation probably depends more on situation as to demand and supply than on the situation as to cost of production.

### Finished Steel

Since last report plates, shapes and bars have declined $1 a ton, the declines occurring early in December, since when the market has been stationary. Quotations now named can occasionally be shaded in the case of large tonnages for prompt shipment, the mills being rather averse to loading up with contract tonnage even at the full quoted prices. Sheets and wire products have also declined $1 a ton, and are not overly firm, for prompt shipment at the new quotations. Prices are f.o.b. Pittsburgh, unless otherwise stated:

Rails, standard section, 1.25c. for Bessemer, 1.34c. for open-hearth, f.o.b. mill, except Colorado.

Plates, tank quality, 1.20c.

Shapes, 1.25c.

Steel bars, 1.20c., base.

Iron bars, 1.35c. Pittsburgh, 1.10c. Chicago, $1.22\frac{1}{2}$c. Philadelphia.

Wire nails, $1.55 per keg, base; plain wire, 1.35c., base.

Sheets, blue annealed, 10 gage, 1.50c.; black, 28 gage, 1.90c.; galvanized, 28 gage, 2.90c.; painted corrugated, 28 gage, 2.10c.; galvanized corrugated, 2.95c.

Merchant steel pipe, $\frac{3}{4}$ to 3-in., 80 per cent off list.

Steel boiler tubes, $3\frac{1}{2}$ to $4\frac{1}{2}$-in., 69 per cent off list.

Standard railroad spikes, 1.50c. Pittsburgh, 1.55c. Chicago.

Button head structural rivets, 1.75c.; cone head boiler rivets, 1.85c.

Cold rolled shafting, 62 per cent off list.

**Cyanidation in the Mercur District, Utah,** is the title of a pamphlet recently issued by the *Salt Lake Mining Review*, giving a history of metallurgical operations in a famous mining district, where the modern vacuum filter was invented. The pamphlet contains many illustrations of milling operations.

### The Non-Ferrous Metal Market

The metal markets generally have been dull, and prices have had a steady tendency downward since our last report. Stocks of metals have accumulated, and purchasers have not been active in spite of lower prices. This fact has led to the belief that even a lower level will have to be reached before buyers will again enter the market.

**Copper.**—About the middle of December prices became practically nominal and the producers sold metal for what they could get. Some foreign business has been done, but the domestic market has been dull. Lake copper is quoted nominally at 14¾c. to 15c., this being practically the price asked by Calumet & Hecla, which is the only Lake producer which has much metal for sale. Electrolytic is quoted at 14.05c. to 14.15c.

**Tin.**—The domestic market has reflected the weak condition of the London market and little business has been done. December tin is lower, being quoted at 37½c.

**Lead.**—Since our last report the leading producer has made two cuts in the price for this metal, and conditions are being reached where some mines will not be able to produce at a profit. New York lead is quoted at 4c. per lb., and St. Louis at 3.85c.

**Spelter.**—This market has been decidedly weak and prices have suffered a sharp decline. Stocks of spelter are accumulating, but buyers remain out of the market. It is felt, however, that prices will not go lower, as buyers are not well covered, and must soon enter the market. New York spelter is quoted at 5.10c. to 5.15c., and St. Louis at 4.95c. to 5c.

**Other Metals.**—The aluminium market is quiet and only a moderate business is done. Prices are 18¾c. to 19¼c. for No. 1 ingots. A similar situation prevails in the antimony market; prices are inclined to be weak, and range from 6c. to 7⅝c. for various brands. The quicksilver market is more steady with fair prices prevailing. New York quotes $39 to $40 per flask of 75 lb., and San Francisco $39.

---

### Symposium of Papers on the Power Problem in the Electrolytic Deposition of Metals

**Joint Meeting of the American Institute of Electrical Engineers and the New York Section of the American Electrochemical Society**

The next meeting of the New York Section of the American Electrochemical Society will be a joint one with the American Institute of Electrical Engineers and the New York Section of the American Society of Mechanical Engineers, at 8:15 p. m., Friday, Jan. 9, 1914, in the auditorium of the Engineering Societies Building, 29 West Thirty-ninth Street, New York City. Dr. C. O. Mailloux will preside. After the meeting members of the section will be the guests of the A. I. E. E. at a smoker to be held in the rooms of the Institute.

The subject for the evening is "The Power Problem in the Electrolytic Deposition of Metals," and the program is as follows:

*The Limitations of the Problem.* By LAWRENCE ADDICKS, Supt. United States Metals Refining Company. (A brief statement of the conditions imposed by practice in the electrolytic refining of copper as a typical process.)

*The Mechanical Side of the Problem.* By H. E. LONGWELL, Mech. Engineer, Westinghouse Machine Company. (Application of gas and steam for driving generators of the type required.)

*The Electrical Side of the Problem.* By F. D. NEWBURY, Division Engineer, Westinghouse Elec. & Mfg. Company. (Application of various d.c. and a.c.-d.c. apparatus to furnish current of the required dimensions.)

The papers will be illustrated and the discussion should be interesting, as the subject is much broader than the typical case chosen for the formal papers.

---

### Meeting of Secretaries of National Technical Societies

Following a call sent out by W. M. Corse, Secretary of the American Institute of Metals, for a meeting to discuss the question of avoiding conflict of dates in the meetings of national, scientific and engineering societies, representatives of fifteen national societies met in the reception room of the American Institute of Mining Engineers, New York City, on Saturday, December 13, 1913. The following American societies were represented by their Secretaries: American Society of Mechanical Engineers, American Institute of Mining Engineers, American Institute of Electrical Engineers, American Chemical Society, American Electrochemical Society, American Institute of Metals, American Institute of Chemical Engineers, American Society for Testing Materials, National Electric Light Association, American Efficiency Society, American Gas Institute, American Society of Gas Lighting, Franklin Institute; besides these, H. D. Vought represented the Railway Engineers and David H. Browne the Canadian Mining Institute. Secretary Stoughton, of the Mining Engineers, served as chairman and W. M. Corse as secretary *pro tem.*

After a long and spirited discussion of various questions needing adjustment, and which it was thought could best be handled by co-operation between the secretaries of the various national societies, the following committee was appointed to serve *pro tem* as a clearing house for announcing to the societies represented the dates of meetings which have been already fixed for 1914, and announcing others as they may be hereafter fixed; also to confer with a similar committee of the Railway Association Secretaries to see whether the two committees could not work in unison, or adopt some uniform plan for future regulation of these questions: W. M. Corse, *chairman;* J. C. Olsen, F. L. Hutchinson, C. W. Rice; Bradley Stoughton, *secretary.* This committee will hold a meeting with the other committee mentioned in the rooms of the American Railway Association, Underwood Building, New York City, on January 10 next at 11 a. m.

It is to be confidently hoped that this move will either stop or reduce to an unavoidable minimum the conflicts of dates in meetings of national societies, which have certainly been annoyingly frequent during 1913.

---

### The Faraday Society

The annual general meeting of the Faraday Society was held on Wednesday, November 26, 1913, at the Institution of Electrical Engineers, in London. The following officers and council were elected to serve for the year 1913-14:

*President*—Sir Robert Hadfield, F.R.S.

*Vice-Presidents*—G. T. Beilby, F.R.S.; Professor K. Birkeland, W. R. Bousfield, K.C.; Professor Bertram Hopkinson, F.R.S.; Professor A. K. Huntington, T. Martin Lowry, D.Sc.; Alexander Siemens, M.Inst.C.E.

*Treasurer*—F. Mollwo Perkin, Ph.D.

*Council*—R. Belfield, Dr. H. Borns, W. R. Cooper, Professor F. G. Donnan, F.R.S.; Emil Hatschek, Dr. R. S. Hutton, Professor Alfred W. Porter, F.R.S.; E. H. Rayner, Dr. R. Seligman, Maurice Solomon.

The seventieth ordinary meeting of the Faraday Society was subsequently held.

A paper communicated by Mr. **Ernest Vanstone** (Birmingham) on *The Electrical Conductivities of Sodium Amalgams* was read in abstract by the secretary.

Continuing the physico-chemical investigation of sodium amalgams the author has determined the electrical conductivities of about twenty alloys. The composition of the alloys varied from 100 atoms per cent. sodium to 54 atoms per cent.

In order to obtain a sufficiently long thread of metal for resistance measurements the alloys were drawn up into a capillary spiral 1 mm diameter and about a meter in length when unwound; platinum terminals were sealed in the spiral at points about a meter apart.

The resistances were measured by a compensation method. Great difficulty was experienced in obtaining a continuous uniform thread.

The conductivity-concentration curve shows discontinuities at concentrations of 15 and 21 per cent mercury and a flat minimum of 35 per cent.

The present paper is a preliminary to a more extensive investigation.

A paper on *The Influence of a Second Solute on the Solubility of Ortho-phthalic Acid*, by Dr. **A. C. Rivett** and Mr. **E. I. Rosenblum**, was read by Dr. Rivett.

The authors have investigated the solubility of orthophthalic acid in solutions of various concentrations of some twenty-six solutes, including twenty-one salts. Their object has been to collect a considerable amount of information which will be available for comparison with similar work on the influence of salts on such other properties of a second solute as diffusion, lowering of freezing point of solvent and reaction velocity.

The form of curve connecting solubility and salt concentration is of the usual type, showing an initial rise followed by a more or less sharp fall. Double decomposition and perhaps increased dissociation of the acid will be partly responsible for the initial rise. In the later part of the curve these become relatively of less importance and at a sufficiently high concentration will be slight compared with the decrease due to so-called neutral salt action. If the curve in its later part be extrapolated to cut the solubility axis at $S_o$, then $S_o$ represents what the concentration of phthalic acid would be in pure water if those conditions alone ruled in approaching it which determine the later part of the curve. Such extrapolation is possible only where the initial rise is very slight. If now the alteration of saturation concentration of the acid depend upon the ions and molecules present, in whatever way these may act, the relation should hold:

$$S = S_o \left\{ 1 + k\alpha C + k' (1 - \alpha) C \right\}$$

where S is solubility and $\alpha$ is degree of dissociation of the salt at concentration C; $k$ and $k'$ are ionic and molecular constants, respectively, of so-called "neutral salt action."

The authors show that it is possible, by choosing suitable values for $k$ and $k'$, to reproduce the solubilities of phthalic acid in presence of LiCl, NaCl, KCl, $MgCl_2$, $CaCl_2$, $BaCl_2$, HCl, KBr, KI, and NaNO , up to concentrations of about 1-molar normal, practically within the limit of experimental error. The calculations involve the usual assumptions as to the possibility of obtaining measures of the degrees of dissociation of salts.

Dr. T. Martin Lowry drew attention to the analogous case of the diminution in solubility of gases in water containing salts in solution.

Dr. E. K. Rideal said that it would have been better to experiment with a substance whose molecule was more symmetrical than that of orthophtalic acid and which would "hydrate" in as simple a manner as possible.

Mr. R. E. Slade remarked that it would be interesting to know the dissociation constant of ortho-phthalic acid, but the author was unable to give it. If there were not much double decomposition on the hydration theory why did $K_2SO_4$ send up the solubility enormously while $Na_2SO_4$ did not?

**The Chairman** said he would like to be able to compare the authors' curves with those given by another solute. In the case of organic radicles it was fairly certain they had hardly any water molecules associated with them.

**Dr. T. Martin Lowry** showed a series of photographs illustrating the *Formation of an Oxidizable Variety of Nitrogen* by the action of a spark discharge on air at atmospheric pressure. The product has the property of being oxidized by ozone to nitrogen peroxide; but if no ozone is added to the gas the yield of peroxide is very small, the greater part of the oxidizable nitrogen reverting under these conditions to the ordinary form. The absorption spectra, which were used to detect and to estimate the nitrogen peroxide, were of interest as having been taken with the help of a column of gas 64 feet in length.

The Chairman said he believed ozone was only produced by a discharge which followed a highly peaked curve.

Professor Alfred W. Porter, F.R.S., in the course of his remarks, referred to the palmleaf-like figures which form, after development, upon photographic plates after passing a negative discharge over them, and which are only obtained in gases containing *free* nitrogen. The figures seemed to indicate that a very loose molecular, ionic, or atomic aggregate travelled with the discharge and ultimately broke up explosively like shrapnel. The immediate product of the explosion was probably Strutt's nitrogen.

A discussion followed on a paper presented at the previous meeting by **Dr. F. J. Brislee** on *The Density of Aluminium.*

The discussion centered round the author's observation that rolling and otherwise working the metal reduces its density, and his explanation of this as due to a transformation from crystalline to amorphous states.

Dr. R. Seligman remarked on the technical importance of the observation, the worked metal being more prone to corrosion because it was amorphous. He agreed as to the probability of the metal changing its state, which would bring it in line with other metals.

Dr. T. Martin Lowry thought that the decrease of density due to rolling might be within the limits of experimental error.

A note communicated to the previous meeting by **Professor J. W. Richards**, of Lehigh University, U.S.A., on *Overvoltage* led to some discussion.

In his note Professor Richards states that it is an error to regard overvoltage as if it did chemical work and was of the nature of decomposition voltage. He regards it as merely due to surface resistance caused by gas on the electrode, so that the energy absorbed appears as sensible heat. This was tested calorimetrically on a voltaic cell.

Dr. F. J. Brislee in a written communication criticized the author's experiments, which seemed to him to prove nothing with regard to the nature of overvoltage. The balance of evidence, however, favored the view that it is associated with the doing of chemical work followed by the degradation of the chemical energy to heat.

Mr. U. R. Evans opposed the view that over-potential was an irreversible electrodic change, involving waste of energy. It required no special explanation, being merely due to the fact that the formation of bubbles required a considerable degree of supersaturation of the cathode with hydrogen. It was a simple phenomenon, quite analogous to superheating a liquid—itself also a surface tension effect.

# The Effect of Legislation Upon Chemical Industries

## Presidential Address Delivered before the American Institute of Chemical Engineers.

BY T. B. WAGNER

At the end of the eighteenth century an observation was made by Scheele in his laboratory, the results of which have meant more to the prosperity of all peoples inhabiting this planet than any other invention—chemical or otherwise. I am referring to the observation which disclosed the fact that cyanide of potassium is capable of dissolving gold. While this discovery was of much scientific interest at the time, and led Faraday to explain it by an elaborate theory, no industrial application was given to it until about one hundred years later.

In April, 1890, the first plant operating under the McArthur-Forest method for treating ore tailings was started in Johannesburg.

The effect of this process is reflected in a tremendous increase of the world's output of gold; consequently, the cyanide process plays an important part in the monetary system of the world, as the increased gold production effected by it has dispelled the fear that there might not be enough of the precious metal to maintain the gold standard of the civilized nations. The struggle in this country for the maintenance of the gold standard is within the memory of all, but I fear that like in other instances, credit was not given to the chemist for his share in having the gold standard preserved.

The recital of this invention has no immediate bearing upon my subject, except in so far as it goes to prove that the furtherance of civilization and the furtherance of industries depend largely upon underlying conditions, which, in their incipiency, may seem trivial. That is the case with the effect of legislation upon the development of chemical industries. The chemical industries of the world are a little over 100 years old, yet, in point of advancement and financial returns, their success is without a rival. Strange as it may seem, the starting of industrial enterprises is not always due to the chase for the almighty dollar, as is generally and perhaps pardonably assumed, but in many instances it is directly caused by the enactment of laws with more or less restrictive tendencies.

Let us go back to the birth of the chemical industries in the beginning of the last century. Napoleon the First whose fame as a stateman and as a conqueror will stand like a beacon light as long as history shall be written, was at war with England. To crush his rival, this far-sighted statesman conceived the idea that the most effective way of accomplishing his purpose lay in the crippling of England's trade. The Continent naturally was the principal buyer of England's colonial products. Napoleon, therefore, in 1806, issued a ukase, according to which England's colonial products were barred from the Continent, and all trade relations with England were forbidden; any country violating this ukase was apt to find itself involved in war with France. This ukase is known as Napoleon's "colonial blockade."

Among England's most important colonial products was cane sugar, but with the enforcement of the blockade, the Continent found itself unable to obtain this sweetening agent, without which life seems to be less sweet indeed. The price of sugar rose enormously and an impetus was thus given to the exploitation of the discovery of Margraf, made in 1747, that the ordinary garden beet root contained considerable quantities of sugar, identical with that found in the sugar cane. The first factory was built in Germany in 1801. Since then this industry has had a marvelous growth, and the present production of sugar from this source exceeds that from cane. The world's production of sugar today is 18,500,000 tons, of which 9,000,000 tons are obtained from the sugar cane, and 9,500,000 tons from the sugar beet.

Of the latter only a little over 600,000 tons are produced in this country, the factories engaged in its manufacture numbering seventy-two.

Incidentally I might mention that while at the beginning of the industry about 20 tons of beets were required for the production of 1 ton of sugar, the same amount of sugar is now obtained from only 7 tons of beets.

It is also worthy of mention here that all of the potassium contained in the sugar beets and fully 65 per cent of their contents of nitrogen are recovered from the molasses and utilized over again. What effect the latest legislation, the new tariff, will have upon the industry in this country, whether it will prove that it has outgrown the state of an infant industry, or whether it still requires the friendly and substantial support of a high protective tariff—that the future will demonstrate within a few years.

Coincident with the establishment of the beet sugar industry was that of another industry which was destined to play an important part in the economic conditions of this country and Germany, viz., the production of grape sugar from starch. The success of this new industry, it may be rightly assumed, is also attributable to Napoleon's exclusion of England's cane sugar from the Continent. The conversion of starch into a reducing sugar, by means of a dilute acid and heat, was discovered in 1811 by Kirchhoff, a teacher at the Imperial Academy of Sciences at St. Petersburg. and the first factory was built in Germany in the same year by the Grand Duke of Saxe-Weimar, at the instance of Professor Doebereiner of the University of Jena, whom you will remember as the inventor of the first "hydrogen lamp."

Bearing in mind the present magnitude of this industry, it is interesting to read of the financing of this pioneer factory in Germany.

I quote from a letter of the Grand Duke to Professor Doebereiner:

"The subscription is assured; my wife and I, my son and his wife are the four stockholders, each contributing 100 talers. I shall advance the capital of 400 talers, which is to bear interest at 5 per cent, and shall turn this over to you; you may then proceed immediately to start the plant. I shall deed my shares to you; I wish you every success and I am convinced that you will proceed carefully. As regards the concession, I believe it can be arranged that it shall be granted for a period of years, however, it must not include the home production of syrup for home use. I intend coming to Jena this week; I shall then bring the money with me and we may discuss further details. I have looked up the manufacture of sulphuric acid in Chaptal & Klaproth. It seems to require a large capital, however, to build the lead chamber."

From this small beginning the industry has grown into one of vast proportions, the yearly production in Germany being 120,000,000 lb., and whereas, at the start, only grape sugar and syrup were produced, and the potato was the only form of raw material, at present by far the largest amount is produced from Indian corn and the number of different commercial commodities produced from the latter reaches almost one hundred. The industry consumes in this country about 50,000,000 bu. of corn annually, or practically one-sixth of all the corn which reaches the markets.

These figures must not be interpreted as meaning a steady and unhampered growth of the industry. On the contrary, if all the legislation which was enacted had had the effect anticipated at the time of enactment, the industry would not have survived these attacks.

For instance, in various states laws were passed putting glucose and grape sugar in the same category as poisons and prohibiting their use in food products. Only last year attempts were made in the legislatures of two states to exclude glucose from use in confectionery, although it is conceded that its use results in a better grade of candy and that certain goods cannot be made without it.

Again when it was discovered by Dr. Ludwig Gall that grape sugar lends itself admirably to the improving of wines, in which the amount of sugar produced by nature is deficient on account of adverse climatic conditions. this method of ameliorating wines, which has come to be known as "Gallizing," was hailed in Germany as one of the most important discoveries, affecting and improving the economic conditions of the provinces in which the wines were produced. Owing to the large demand which Dr. Gall's discovery created for this sugar, it contributed materially to the growth of the industry. Yet we find that only a few years ago conditions were reversed by legislative action and great restrictions were placed upon the use of this sugar in the amelioration of wines.

In this country the controversy over the use of sugar in wines, only a few months ago, almost caused the failure of the new tariff act. Our domestic wine industry is centered principally in the State of California one one side, and the States of Ohio and Missouri on the other. California produces grapes rich in sugar, whereas even the best grapes produced in Ohio are deficient in sugar to such an extent as to produce a wine so low in alcohol as to be almost unmerchantable. The Ohio and Missouri wine producers therefore resorted to "Gallizing" ever since the industry was started in their states, about 60 years ago. Their ameliorated wines are said to be as good as any produced in California, yet the wine producers of that State tried to create the impression in Congress and elsewhere that California wines were the only pure wines, whereas those produced in Ohio and Missouri were adulterated because of the addition of sugar.

In the production of sweet wines it becomes necessary to "fortify" the wines with brandy, and the California people succeeded in having an act passed by Congress in 1890 which permitted them to use brandy without paying the spirit tax of $1.10. It is said that since the passage of this act the amount of money saved to the California interests was not less than $63,000,000.

To retaliate against California, the Ohio and Missouri interests appeared before Congress when the Underwood tariff bill was under consideration. One section of the tariff act deals with the income derived from internal revenue, and here the Eastern interests saw their opportunity and introduced a bill which would take from the California wine producers the privilege of using tax-free brandy. It would compel them to pay into the United States Treasury annually something like $8,000,000.

The California interests answered in kind by introducing a bill placing a tax of 25 cents per gallon upon all wines produced in the territory east of the Rocky Mountains, which, if enacted into law, would mean the annihilation of the industry in that territory. This in turn would injure the grape sugar industry, as it would curtail the consumption of grape sugar.

Further consideration of the tariff bill came to a standstill, as this so-called wine clause proved the stumbling block, and no headway was made until the entire wine clause was eliminated for the time being—Congress agreeing to give it its attention during the regular session.

I cite these cases to show the influence of legislation, even though indirect, upon the development of a chemical industry. What is one's loss is another's gain. For instance, the loss of the sugar business to England meant the birth of two important new industries and these in turn influenced the development of other branches of the chemical industries. It is but fair to state that the chemical industries in general owe a great deal to the beet sugar industry. Looking over the list of early chemists and chemical engineers, who have distinguished themselves in the chemical industries, we find that most of them had their start in a beet sugar factory—likewise many successful works managers, for it was in this industry that the first complicated machinery was installed. The modern evaporating devices as well as the separation of solids from liquids by centrifugal force, had their inception in beet sugar works.

I cannot leave this chapter without mentioning another instance bearing upon the beneficial, although unlooked for, results of restrictive legislation. A number of years ago a law was enacted in one of the wine-producing countries abroad with reference to wines made from the residue of the pressings of the grapes, the so-called "pomace" wines. These wines were introduced by Petiot, a French wine merchant, and were produced from Bordeaux wines by adding a sugar solution to the residue from the first must and fermenting a second time. The alcohol generated thereby dissolved coloring substances, as well as tannin and the flavoring principles, the "bouquet." This treatment is known as "petiotizing" and is applied to Bordeaux wines four or five times in succession.

Much sophistication was practiced—the pomace wines being sold frequently as natural wines. The Government recognized the legitimacy of the "pomace" wine business, but it wanted these wines to be sold for what they were and did not want them sold to the public under a misleading name. The wines were supposed to be sold as "pomace wines," and to enable the Government officers to distinguish them from "natural" wines, and to identify a pomace wine, the law provided that these wines must receive, before marketing, the addition of a small amount of phenolphthalein. The inspector would examine the wines by adding a few drops of an alkaline solution which, of course, would turn the color red. If the color of a "natural" wine turned red it was *prima facie* evidence that a pomace wine had been substituted.

After this law had been in effect for about a year it was observed that peasants living in the district where these pomace wines were produced and consuming rather large quantities of these wines developed what was then considered a disease and which assumed the proportions of an epidemic. The Government dispatched its medical officers to make a thorough investigation and subsequently they reported that they believed phenolphthalein to be the cause of the trouble. Thereupon clinical tests were instituted and the fact established that phenolphthalein was a most effective cathartic. While heretofore phenolphthalein was used primarily in the laboratories as an indicator, it now assumed an important position among our therapeutic chemicals and is at present manufactured in very large quantities.

Before leaving the subject of sugars, I must not omit a reference to saccharine, a substance which has received extensive attention at the hand of legislative bodies. As you know, saccharine was discovered by Dr. Fahlberg, while taking a post graduate course with Professor Ira Remsen at Johns Hopkins University. It was more or less an accidental discovery, as Dr. Fahlberg's work was in the direction of coal tar derivatives from a purely scientific point of view. The manufacture of this new sweetening agent was started in Germany and a new industry created which grew in importance so that it was eventually considered a menace to the beet sugar industry of the Continent.

The latter, of course, is of greater importance to Continental countries, from an economic point of view, and the new rival of beet sugar was therefore discriminated against by laws which prohibited the use of this sweetening substance as a substitute for sugar, permitting its employment solely for medical purposes, the Governments of Germany and Italy going so far as to prohibit the manufacture of the article itself. It was not prohibited because the article was injurious to health, but simply because of economic considerations. The importation into Germany being prohibited, it is interesting to note the accounts in the trade papers of the vast amount of smuggling from Switzerland into Germany.

Incidentally this shows that notwithstanding the prohibition of saccharine in food, a large demand for it still exists, and I am told that it is used chiefly in the households for sweetening jellies, jams, preserves and similar products in place of the expensive beet sugar, rather than by the manufacturers of such products. I read an account in one of the trade journals recently, according to which it was observed for some time by the Customs authorities that an astonishingly large number of funeral parties crossed the Swiss frontier into the adjoining Grand Duchy of Baden—the explanation given being that the bodies were shipped into Germany in conformity with the wishes of the deceased to be buried in their native land. The number of funeral parties steadily growing in numbers, the Customs authorities finally had their suspicions aroused and ordered a casket to be opened. It was discovered that in place of the supposed corpse, the casket was filled with packages of saccharine!

The most far-reaching legislation ever enacted was that directed against the discharge of sulphurous acid fumes from ore smelters. With the increased output of these smelters, the volume of sulphurous acid discharged into the air became so large as to produce a most destructive effect upon vegetation. Laws were enacted in this country, as well as abroad, to the effect that unless the sulphurous acid fumes could be rendered harmless the operation of these smelters would have to be stopped. The first attempts to convert them into a useful article were in the direction of compressing the gases into liquid sulphurous acid, which was used in the manufacture of glue and gelatine, but the amount of gas recovered from the furnaces grow so enormous that this outlet was not sufficient.

The attempts were then directed to oxidizing the sulphurous acid by means of the oxygen of the air for the production of sulphuric trioxide, following the reaction discovered by Clemens Winkler. These efforts proved extremely successful and works were soon established where $SO_3$ and finally sulphuric acid was generated from the waste sulphurous acid gases. In this manner a new process for manufacturing sulphuric acid was created, the so-called "contact process," which, in the course of time, thoroughly revolutionized a branch of chemical industry, in which the old established chamber process had come to be considered impossible of improvement.

I am particularly pleased to be able to refer in this connection to the splendid work of our fellow member, Mr. J. B. Francis Herreshoff, whose contact process has proved so superior to that of the Badische Anilin and Sodafabrik in point of economy and simplicity of operation that it is now being introduced into Germany.

The utilization of the waste gases from smelters had the effect of producing cheap sulphuric acid in localities where it would have been impossible to produce it by any other method. This had the most beneficial effect upon the development of the fertilizer industry in this country. Our Southern States, principally Florida and Tennessee, furnish today the bulk of the world's requirements of phosphatic rock. Liebig showed us how this insoluble phosphorus could be converted into a soluble form by a treatment with sulphuric acid, and for this purpose alone over 3,000,000 tons of acid are used per year.

The contact process, in turn, was responsible for the successful commercial production of synthetic indigo. The most successful method of producing it is a combination of methods suggested independently of each other, and consists in the following steps:

1. Naphthalene to phthalic acid.
2. Phthalic acid anhydride to phthalic imide.
3. Phthalic imide to anthranilic acid.
4. Anthranilic acid to phenylglycin ortho carbonic acid.

5—Phenylglycin ortho carbonic acid to indigo.

The greatest problem was the production of phthalic acid. Heretofore it has been obtained through the oxidation of naphthalene by chromic acid. The latter, however, was very expensive and this method did not hold out much hope of commercial success. E. Sapper, a chemist engaged in experiments to reduce the cost of production of phthalic acid, conceived a new process of making it by heating naphthalene with highly concentrated fuming sulphuric acid. After years of experimenting a suitable method was found in the discovery of which Accident, the patron saint of the inventor, played an important rôle. It was discovered that the addition of mercury to the solution of naphthalene in fuming sulphuric acid facilitated the reaction and resulted in an almost theoretical yield.

We must bear in mind, however, that the commercial success of synthetic indigo was influenced, to a large extent, by the fact that the $SO_2$ generated by the process of heating naphthalene with sulphuric acid could be reconverted into $SO_3$ by the contact process. Even 10 years ago one single establishment engaged in the manufacture of synthetic indigo reconverted into $SO_3$ 40,000 tons of sulphurous acid per year, obtained in the manufacture of phthalic acid.

Thus we have seen that through the instrumentality of the law, a chemical process was introduced into metallurgical establishments, the contact process was created, a cheap supply of sulphuric acid was secured, which in turn proved a blessing to agricultural interests through the production of a cheap fertilizing material, and finally it made possible the commercial exploitation of one of the finest achievements of scientific effort—the production of synthetic indigo.

Another impetus was given to chemical industries by laws aimed at stopping the contamination and pollution of rivers and other waters. Before the value of by-products was understood by manufacturers, the rivers and waterways in general were used as the most convenient and inexpensive way of removing offal and waste of all kinds from the factory.

It is not difficult to understand the results from such abuse of natural water courses. The communities deriving their supply of drinking water from these sources were especially affected by it; the water, deprived of its natural content of oxygen, caused the death of the fish habitating in these waters and the odor produced by the decomposition of this offal brought much discomfort to the people living within the vicinity of such streams. It was a condition of which the Legislatures were compelled to take cognizance, and the inevitable result was the prohibition of such use.

This legislation proved disastrous to many industries but it proved of the greatest benefit to a far larger number. Among others, it affected beneficially all the industries connected with fermentation and those connected with the manufacture of starch from various raw materials. The materials recovered from the waste of these industries were converted into dry form, serving, in most instances, for the feeding of cattle and live stock. Such feeds are those produced from the starch works, distilleries and breweries, and they rank among the most valuable concentrated feeding stuffs. They are indispensable for the rational feeding of live stock, which, together with wheat, form the principal means of sustenance of mankind. The production in this country of foodstuffs from the manufacture of starch alone amounts to over 300,000 tons per year, and since these foodstuffs sell at approximately $25 a ton, the revenue obtained from this source amounts to $7,500,000 per annum.

In former years it was customary to allow the germs of the corn to go to waste, but today the industry recovers about 75,000,000 lb. of oil per year, which is sold in the markets of the world at about $4,500,000. The corn solubles—the so-called steep water—is now recovered to the extent of 100,000,000 lbs. a year, which is sold also in the world's markets at over $1,000,000. The by-products recovered from distilleries and breweries in this country may be said to be worth about $5,000,000 per year.

One of the most prolific sources of legislation is oleomargarine. Laws have been enacted in many States aimed at the destruction of this industry, as for instance the oleomargarine laws of Pennsylvania and New Hampshire, which required that no oleomargarine should be sold in those States unless it were colored pink. Yet, in spite of these restrictive, if not prohibitive, laws, this industry has prospered, simply because of the underlying merit of the product itself. This is well illustrated by the fact that the receipts of the internal revenue office from the tax on oleomargarine amounted to $1,259,987.65 during the fiscal year ending June 30, 1913.

This subject furnishes a most interesting sidelight on the incongruities of laws. The artificial coloring of natural butter is permitted by a special act of Congress, even though the butter color used at the time of the enactment of this law would not be permitted today under the Federal Food & Drugs Act because of its injurious character.

The artificial coloring of oleomargarine, however, is not permitted, because such practice would make it an imitation of butter. If, however, the producer of oleomargarine is willing to pay a tax of 10 cents per pound, he then acquires the right to put his "fraudulent" product upon the market and the Government becomes his silent partner. Most of the oleomargarine is produced by the packers, but it is only one of a large number of chemical products manufactured by them.

It is only a relatively short time since chemistry has entered the packing houses and it was not entirely a matter of choice that led to the entry of the chemist, but rather stern necessity, for the law had served notice upon the packers that a stop would soon be put to their practice of discharging their enormous putrefactive wastes into creeks and rivers. This could not be accomplished without the aid of the chemist and the chemical engineer.

As a result of their work, the packers produce today not only meats, meat extracts and soups, but they manufacture lard, tallow, stearine and oleomargarine. They also produce soaps, candles and hydrogenated fats; in the manufacture of these products, they recover glycerin as a by-product. From the different parts of the animal, especially from the pancreas, the thyroid and the suprarenal glands, therapeutic agents of great medicinal value are obtained.

From the stomachs of hogs pepsin is produced and the use of the latter has been greatly increased within recent years by the clever discovery of two brother chemists, the Messrs. Wallerstein of this city, that beer of absolute chill-proof quality is obtained by the use of pepsin. The governing thought of their invention lay in the desire to keep those albumenoid substances in colloidal solution which could not be separated during the process of refrigeration; the use of a minute quantity of pepsin makes this possible.

Further by-products of the packing houses are glue and gelatine, both products of great importance, particularly in view of the universal shortage all over the world of glue stock, and the correspondingly high prices prevailing for these products. The bones of the slaughtered animals are charred for the preparation of bone black, which, as you know, is a valuable filtering and refining material. In other departments of the packing plants brushes are made from the bristles of the hogs. The hair is also recovered and the skins and hides go to the tanneries to be converted into leather. What is left is placed on the market as fertilizing materials, as for instance, dried blood and tankage.

Viewing these remarkable results, it is obvious that there is hardly any necessity of further legislation for the disposition of offal from the packing plants.

Other industries directly affected by legislation prohibiting the pollution of streams are the paper and pulp industries. Here, however, the problem of a satisfactory disposition of the objectionable materials offers greater difficulties than in most of the other industries. Some of the waste material is recovered through mechanical separators, but most of it still goes to waste, and this has resulted in the closing by law of a number of plants.

A beginning towards recovery has been made through the Mueller-Kestner process whereby the spent sulfite liquors are neutralized and then concentrated in a vacuum system. The liquid thus obtained is used principally for laying dust on roads in the same manner as petroleum oils are used in this country.

In Sweden attempts are being made to produce ethyl alcohol from sulfite liquors and the results are claimed to be quite satisfactory, but while these are steps in the right direction, the great problem affecting these industries still remains unsolved.

In this connection I do not think it amiss to point out another incongruity of laws as enforced in various countries and the discrimination shown against certain products. One of the greatest wastes in this country is that of the lumber industry. The waste in that particular industry is appalling and when we recall the strenuous efforts toward conservation of our natural resources, one stands aghast at the wanton waste still going on in that industry, for wherever you see a lumber mill of large capacity you will invariably find a burner installed where such wood waste as cannot be used in the production of steam is incinerated, and millions of dollars worth of material escapes unused into the air in the form of gases.

During the last few years an industry has been started in this country based upon the observation that cellulosic materials can be converted into reducing sugars, from which ethyl alcohol may be produced. There is only one plant in operation thus far, but the results obtained seem to indicate that this new method of producing ethyl alcohol is commercially feasible and lucrative. The cash capital invested in this plant amounts to $1,000,000. The product obtained is of the very highest grade, practically free from fusel oils and surpassing that produced in grain distilleries, yet the most natural outlet for ethyl alcohol is closed to this industry, because our laws provide that only grain-distilled spirits may be used in the compounding of whiskeys. In Canada, however, no such restrictive legislation exists because there the law simply provides that ethyl alcohol may be used irrespective of its source. It would not be surprising, therefore, if the development of this new industry would prove speedier in Canada than in this country.

Of much interest to chemists is a bill recently introduced in Congress by Representative Falson of North Carolina, providing for an appropriation of $400,000 to enable the Department of Agriculture to procure economical methods for the production of artificial fertilizers by means of electricity. It would seem that official circles have taken cognizance of the fact that the saltpetre deposits in Chile are not far from complete exhaustion, and that our lawmakers have arrived at the conclusion that they can rely upon the chemist to meet the situation—producing a cheap nitrogenous fertilizing material in place of saltpetre, which can be secured in unlimited quantities.

You all know that the utilization of nitrogen from the air by the combination of nitrogen and oxygen of the atmosphere with the formation of nitric acid is an accomplished fact.

In the form of a new chemical compound, called calcium cyanamide, which is produced by combining nitrogen from the air with calcium carbide, a plant food is obtained which, as a fertilizing agent, is as efficient as Chile saltpetre or ammonium sulphate. The production of these substances from atmospheric nitrogen will therefore remove the anxiety of many writers on economics concerning the difficulty of feeding an ever-increasing population, owing to the gradual exhaustion of the soil.

Since nitric acid is also used largely for nitrating glycerin, cotton and cellulose, and since these nitrated products are the principal constituents of the smokeless powder and high explosives used by the armies and navies of the world, it is apparent that aside from its importance from economic considerations, a process of making nitric acid independently of Chile saltpetre will become of extreme importance in case of war, for it removes the danger of being cut off from the supply of Chile saltpetre by a hostile navy.

As yet, the principal production of nitric acid from atmospheric nitrogen is centered in Norway, because that country has natural water power of a tremendous magnitude, with the further advantage of being located within easy reach of the principal markets abroad. Even in Norway, however, restrictions have been placed by law upon this new industry—the law providing in effect that only citizens of Norway may be engaged in the exploitation of these natural water powers. This caused the severance from the Norway enterprise of Dr. Schoenherr, one of the pioneers of this new industry.

The time at my disposal does not permit of enumerating all that has been accomplished in the utilization of industrial wastes through the compelling force of legislation. The aniline industry, the production of sulphate of ammonia from gas residues, of copper as from pickling liquors in steel and wire works, of copper, zinc and nickel from plating works, of fats and soaps from textile mills, and the products obtained in the reduction of garbage would all come under this heading. The last named subject alone is not only of the greatest importance and greatest interest, but in itself would suffice for a complete address.

I believe I have shown that what may at first have seemed oppressive legislation actually developed into progressive legislation, and led to the building up of important chemical industries, which, in point of commercial value, as well as in point of direct benefit to mankind, rank second to none. And now when fears are expressed regarding the commercial and industrial future of this country because of the present tendency to disband large industrial organizations and corporations, I believe the chemist has no cause for apprehension, for it is the chemist, first of all, who is sought in times of need. His services are appreciated all the more when competition calls for a greater exercise of scientific knowledge and of technical skill. This holds good even with respect to the effects of the new tariff. While the removal of a high protective tariff may bring hardships to certain industries, the ingenuity of the chemist and chemical engineer will assert itself and lead us to conditions possibly more equitable than they have been in the past. I believe that it will always be a case of history repeating itself, and I cannot see other than a most hopeful future for the chemical industries of this country.

## The Dunn Pulverized Coal Burner

BY G. A. ROUSH

One of the most important improvements in recent years in the manufacture of Portland cement is the introduction of the powdered coal burner in the kilns for the burning of the cement clinker. The wide success of pulverized fuel in this style of furnace has led to numerous attempts to apply it to various metallurgical operations, but without much success until recently. Probably the best known installation for metallurgical work is at the plant of the Canadian Copper Company, Copper Cliff, Ont., where 50 tons of pulverized coal per day are burned in the reverberatory matting furnaces. After an examination of the Copper Cliff installation it has been decided to put powdered coal burners in the reverberatory furnaces of the Anaconda Copper Company, at Anaconda, Mont.

The principle of the pulverized coal burner is, by means of a screw or some other device to feed a continuous stream of powdered coal into a blast of air issuing from a nozzle at high velocity, and then to convey this mixture of coal and air to the furnace, where the coal dust is ignited by the heat radiated to it from the walls of the furnace. The main difficulties encountered are securing a perfectly uniform feed of coal dust, and getting it evently distributed and suspended in the blast of air. These difficulties may result in incomplete combustion or an unnecessary amount of excess air, and "back-flashes." A form of burner that has practically entirely overcome these difficulties has been developed by Mr. William R. Dunn,[1] Superintendent of the Vulcanite Portland Cement Company, Vulcanite, N. J. The fact that this burner is now being installed for metallurgical work, and that it has a remarkable applicability both in large and small units, makes it of special interest.

---

[1] U. S. Patents 951,944, Apr. 12, 1910, and 1,028,997 June 11, 1912.

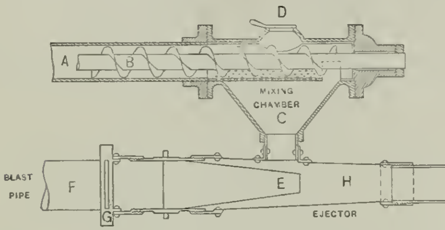


FIG. 1 PULVERIZED COAL FEEDER

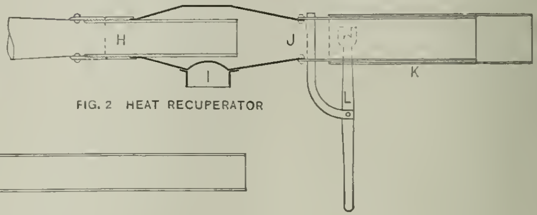


FIG. 2 HEAT RECUPERATOR

The construction of this burner is shown in Fig. 1. *A* is the feed pipe to the storage bin; *B* is the feed screw; *C* is the mixing chamber; *D* is an air valve; *E* is the air nozzle from the blast pipe *F*, the supply of air from which can be regulated by the gate valve *G;* *H* is the ejector to carry the mixed coal dust and air to the furnace. The important point in the construction of the burner is that, instead of allowing the coal to drop to the air nozzle just as it is fed by the screw, with more or less irregularity due to a slight amount of adhesion of the coal particles, the coal is carried along by the screw and gradually fed out through the perforations in the feed plate, the size of the perforations and the speed of the screw being so regulated that the coal just reaches the end of the perforated plate, for the maximum capacity of the feeder. This method of feeding completely does away with irregularities in the coal supply, and at the same time gives a more uniform suspension of the coal dust by drawing in a portion of the air through the valve *D* by the injector-action of the air jet at *E*, the air thus drawn in mixing with the coal in the chamber *C*, instead of depending, for the entire distribution of the coal dust, on the action of the air jet from *E*. This uniformity of feed and suspension makes it possible to regulate the air supply very closely, so that only a small amount of excess air will be required by the combustion, and entirely does away with the "back-flashes" that result from lack of uniform mixing of the air and coal. By regulating the valves *D* and *G*, the proportion of the total amount of air required that is mixed with the coal in *C* can be controlled, as demanded by the composition of coal, and other conditions of combustion.

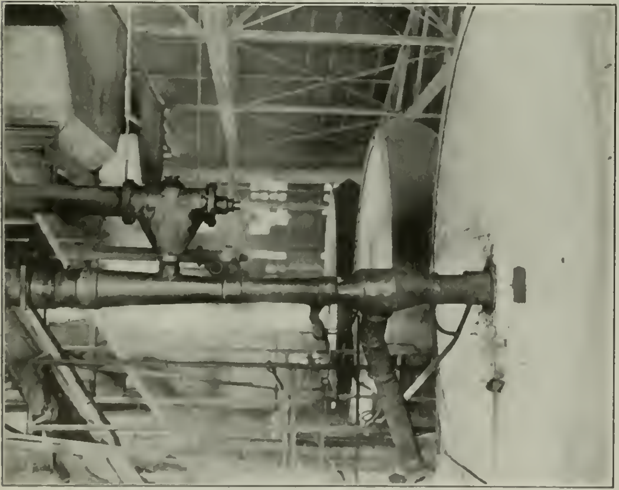


FIG. 3—POWDERED COAL BURNER (CAPACITY 2600 LBS. PER HOUR)

As applied to the cement kiln, the burner is supplied with the "heat recuperator" shown in Fig. 2. Only about two-thirds of the air required for the combustion is supplied at *D* and *G*, the remainder being drawn in through *I* by the injector-action of the blast of air issuring from the ejector *H*. From *I* a pipe leads to the pit under the kiln into which the hot clinker is discharged, so that the air drawn in is slightly preheated. This of course amounts only to a small saving, but since the cost is no more, it is worth while.

The length of the pipe leading into the kiln can be regulated by the sliding sleeve *K* and the lever *L*. The distance from the kiln wall to the end of the pipe has considerable influence on the shape of the flame.

Fig. 3 shows an installation of these burners in the Vulcanite plant, burning 2600 lb. of coal per hour, in kilns 125 ft. long, 7 ft. inside diameter and 8 ft. 6 in. outside diameter, using an air pressure of 8 oz. and a coal, 94 per cent of which passed a 100-mesh sieve. Sixty-foot kilns just beyond these were burning 800 lb. per hour. The flame was about 20 ft. long and the coal ignited at only 4-6 in. from the end of the ejector pipe of the burner. The stack gases left the kiln at 500-550 deg. C. The condition of the end wall of the kiln speaks for itself in regard to the absence of "back-flashes"; these always smut and blacken the wall, but this wall had not been whitewashed for over 30 months.

The substitution of these burners for oil burners in these kilns resulted in a saving of approximately 75 per cent of the fuel cost in calcining, and at the same time, the capacity of the kiln was increased by some 25 per cent.

These burners are working satisfactorily in units as small as 50 and 75 lb. per hour, and it is thought that these smaller sizes can be successfully applied to steam boilers, with a considerable saving of fuel.

Judging from the characteristics and construction of this burner, and from its past record it is probable that other metallurgical applications will soon be developed.

*Lehigh University,*
*South Bethlehem, Pa.*

# Concentration of Complex Sulphide Ore from the Mary Murphy Mine

BY H. C. PARMELEE

The concentrating mill of the Mary Murphy Gold Mining Co. is situated near Romley, Colo., about 25 miles southwest of Buena Vista, on a branch of the Colorado & Southern Railway. The mines are located in one of the oldest districts in the state, and have been largely productive for 34 years. They were discovered in 1874, and the first extensive work was done in 1879. At various times during the history of the property, reduction plants have been built and operated—an old mill at Romley, and a smelter at Buena Vista. The present mill was built last year and has been in operation since last February.

The mines produce two classes of ore: relatively high-grade gold-silver ore, oxidized and suitable for direct smelting; and low-grade ore containing mixed sulphides of lead, zinc and iron, which must be concentrated and separated into products suitable for lead and zinc smelting.

The valuable metals in the milling ore are gold, silver, lead, zinc and copper, none of which exists in sufficient quantity to make the ore valuable for itself alone. Thus, the assay value of about 4000 tons of ore crushed in September was: gold, 0.25 oz. per ton; silver, 3.1 oz. per ton; zinc, 8.7 per cent; lead, 5.4 per cent (wet); copper, 0.6 per cent. Both mineralogically and physically the ore falls within that class denominated "complex," and the concentration problem is one of securing the best economic recovery rather than the highest metallurgical saving.

### A Complex Milling Problem

The complexity of the problem is increased by the physical occurrence of the precious metals and base minerals. The gold occurs free and usually finely disseminated, and the sulphides are generally fine-grained and intimately mixed. The preparation of the ore by crushing and grinding thus becomes the crucial feature of the process. In order to make a high gold recovery the ore should be ground comparatively fine; on the other hand, this procedure entails high loss of the lead and zinc minerals, both of which should be recovered as coarse as possible. Grinding machines that are best suited to the liberation of the gold and silver are inappropriate for the preparation of the base minerals for concentration. The whole problem thus resolves itself into finding and maintaining that happy medium between metallurgical loss and economic recovery of the several metallic constituents, which shall finally result in the greatest net profit for the whole operation.

It has been stated that the gold occurs free and finely disseminated. Metallic gold has never been observed in any of the ore deposits or specimens. Nevertheless a considerable quantity is recognizable by amalgamation; and there is a sporadic occurrence of coarse gold in the ore, for occasionally it is found on the jig screen in nuggets as large as 1/3 in. in diameter.

The methods of concentration employed at the Mary Murphy mill are shown in detail on the accompanying flow-sheet, Fig. 1. In brief, the features of the process are as follows: Coarse concentration begins on jigs, the limiting sizes of the feed being 4.75 mm (3/16 in.) and 1 mm. The portion minus 1 mm is classified for treatment on tables and vanners. The coarsest clean concentrate produced is galena from the hutch of the first compartment of the jig, the screen used being 2 mm. The coarsest tailing discharged is the finer portion of the sand from the table treating the coarsest grade of the minus 1 mm feed. Amalgamated plates and carpets are used for the recovery of free gold and silver.

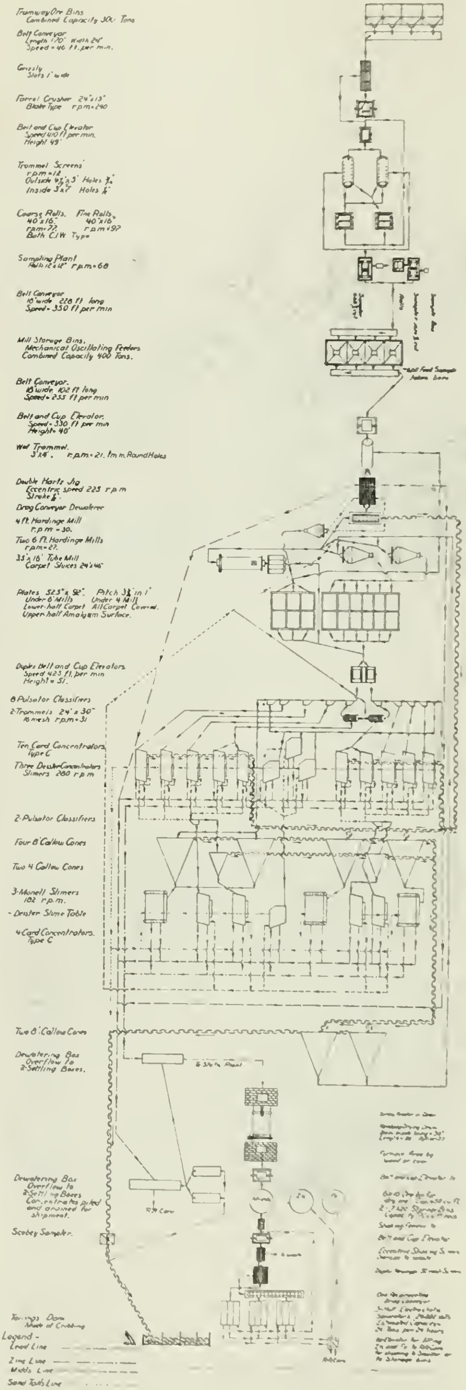


Fig 1 FLOW SHEET of the MARY MURPHY MILL

Final zinc concentrate is produced only by electrostatic separation of the zinc-iron middlings from the various tables.

### Arrangement of Plant

The mill site is located at the mouth of the Golf tunnel, a cross-cut driven before the mill was erected, and which ultimately will be connected with the mine workings and used for the transportation of ore. At present ore is delivered to the mill by aerial tramway. A general view of the mill is shown in Fig. 2, and a view from the opposite side, showing the mill terminal of the tramway, in Fig. 3.

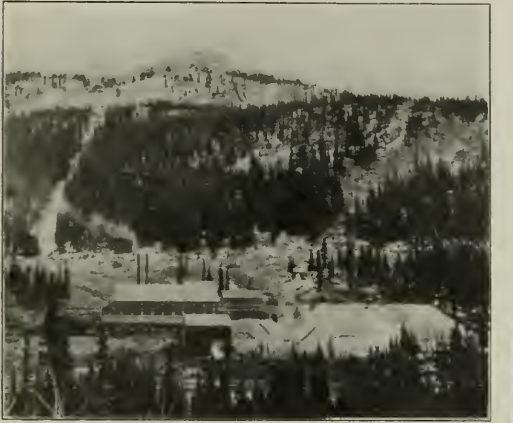


FIG. 2—CONCENTRATING MILL, MARY MURPHY G. M. CO., ROMLEY, CHAFEE CO., COLO.

The concentrating and electrostatic-separating units are separately housed, the latter being in the small building in the foreground of Fig. 2. The lowest floor of the mill is on a level with the top floor of the electrostatic plant, an arrangement which facilitates the handling of the zinc middling produced in the former and treated in the latter.

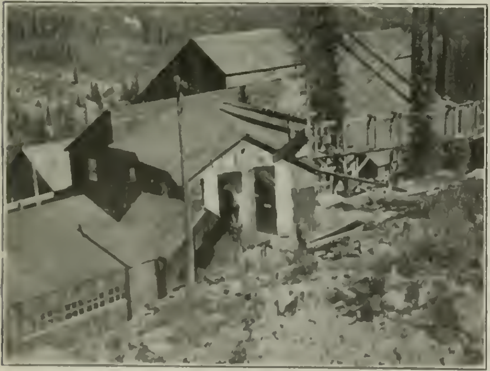


FIG. 3—VIEW FROM ABOVE MILL SHOWING TRAMWAY TERMINAL.

The concentrating machinery in the main mill is arranged on three floors. On the upper floor Card and Deister tables are placed symmetrically on each side of the central duplex wet elevators which deliver pulp to duplicate lines of Richards launder-type pulsator classifiers. A suggestion of this arrangement is given in the flow-sheet, and is shown also in Fig. 7. On the middle floor are Card and Deister tables and Monell vanners, the former retreating middlings from the corresponding tables above, and the latter thickened slime. The bottom floor is devoted to the regrinding machinery, amalgamating plates, and collection and storage of concentrates.

The arrangement of the entire plant permits of flexibility in operation. Storage bins for crude and crushed ore have ample capacity to insure steady operation of the mill without interference from the ordinary delays on the tramway or in the crushing department. The latter is designed in generous proportions, and usually prepares in 8 hours the mill feed for a 24-hour period. The arrangement of the upper and lower table floors in right and left-hand units, in combination with two pulp elevators, makes it possible on occasion to divert temporarily the entire feed to one side or the other.

The regrinding machines, one 4-ft. and two 6-ft. Hardinge mills, and one $3\frac{1}{2}$-ft. by 16-ft. tube mill, have more than sufficient capacity to meet the daily demand, so that, according to a recent change in operation, the small Hardinge can always be kept in reserve. In addition to the convenient arrangement and ample capacity of the machinery, there is plenty of room in the mill for making additions or alterations, and for the storage of concentrates during a part of the winter when railroad transportation is discontinued.

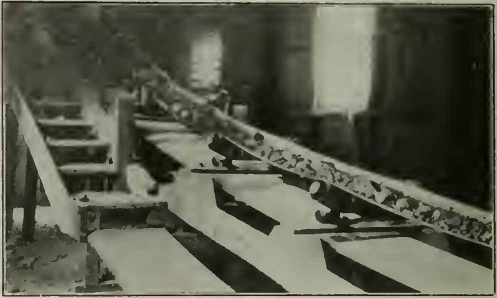


FIG. 4—SORTING BELT BETWEEN CRUDE-ORE BINS AND CRUSHER

### Crushing, Grinding and Sampling

Referring to the treatment in greater detail: The ore is conveyed from the crude-ore bins to the grizzly and crushed by means of a belt, shown in Fig. 4. From this belt the final sorting of waste is made, supplementing similar work in the stopes and at the upper tramway terminal. On an average, over one ton of waste per day is sorted out. In September the waste at this point amounted to 36 tons, or 1 per cent of the ore crushed. The main object of the sorting is the elimination of wood, pieces of steel, frozen dynamite, etc.

All of the ore is crushed and rolled to pass a 3/16 in. screen. Crushing and grinding are done dry, but provision is made to run the rolls wet in case the mine ore should become so moist as to stick badly. With wet roll crushing it would be necessary to dewater the product before delivery to the mill storage bins, and for this purpose a drag dewaterer is ready for use when occasion demands. The trommels carry two screens, inner and outer, with $\frac{5}{8}$-in. round holes, and 3/16-in. slots respectively. Their oversizes are reground in coarse and fine rolls; the undersize of the outer screen, 3/16-in. (4.75 mm.), is the finished product.

Before delivery to the mill storage bins the ore is sampled. The stream of ground ore falling vertically from the screens is cut at regular intervals by buckets supported by endless chains traveling horizontally. The first cut is reground in rolls and again sampled in a similar manner, giving finally a sample amounting to 0.1526 per cent of the ore crushed. The reject from the sampler is conveyed to the distributor above the storage bins, shown in Fig. 6.

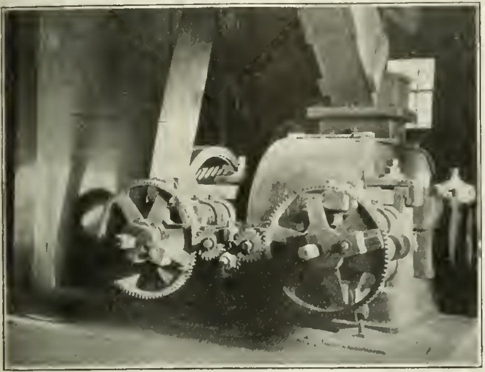


FIG. 5—ONE OF TWO 40-IN. BIG 16-IN. ROLLS, WITH DRY ELEVATOR BETWEEN

The automatic sample represents the metal contents and tonnage of ore crushed and delivered to the mill storage bins each day, but it offers no check on the ore milled during the day on which the sample was taken. The daily mill-feed is hand-sampled every 30 minutes as it leaves the storage bins to enter the concentrating system. Except for the fact that the mill-feed probably is more uniform in value than the mine ore, due to the mixing accomplished during crushing, grinding and distributing, the hand sample is likely to be less reliable than the automatic; and a closer check on the mill work might be obtained through a second automatic sample of the actual daily mill-feed. As far as gold is concerned, however, the tailing for any one day has little relation to the actual feed for that day; a feed temporarily high in gold shows higher gold loss in the tailings for a week or more.

### Jigging

Water is added to the ore at the wet trommel, where the split is made between jig and table feeds. The trommel screen has 1 mm round holes; the oversize constitutes the jig feed and the undersize flows first over carpets and thence to the duplex elevators, classifiers and primary tables.

The work of the jig necessarily varies from time to time with the nature of the feed. It is intended to produce a clean galena concentrate from the hutch of the first compartment; zinc-lead-iron middlings from the hutch and side gate of the second compartment; and tailings of quartz and rhodonite still enclosing some mineral. The production of concentrate will occur only when the ore carries comparatively coarse-grained galena; otherwise, when the sulphides are fine-grained and more intimately mixed, middlings will be produced from both compartments.

Both the midding and tailing require regrinding, but in a different degree. The flow-sheet shows the middling flowing to a 4-ft. Hardinge mill, and the tailing distributed among two 6-ft. Hardinge mills and one tube mill.

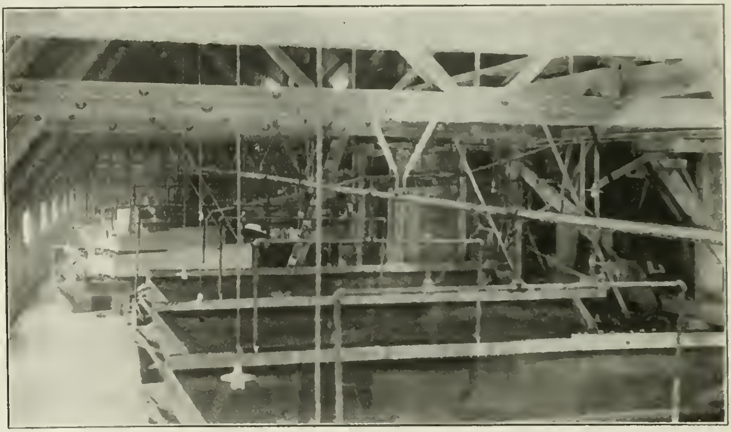


FIG. 7—UPPER TABLE FLOOR. TABLES ARRANGED AT EITHER SIDE OF DUPLEX ELEVATORS IN CENTER

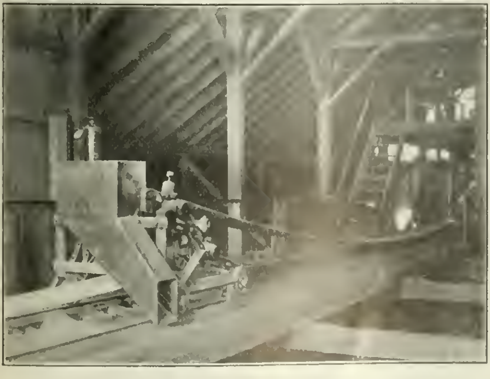


FIG. 6—DISTRIBUTOR ABOVE CRUSHED-ORE BINS

### Effect of Regrinding Mills

Experience with the Hardinge mills on this ore indicates that they are satisfactory in regrinding tailings of quartz and rhodonite, but are not so well suited to the regrinding of middlings, as they produce too much mineral slime. For this reason one of the important changes recently made in the treatment is the substitution of a set of 14 in. by 27 in. rolls for the 4-ft. Hardinge mill. These rolls are to be set close, and are expected to accomplish the regrinding of the middling with the production of less slime.

The following figures are fairly typical of the work done in the four regrinding machines. The pulp samples were taken on the same day, with the plant running under normal conditions, treating 125 tons of ore in 24 hours. The screen tests were made on dry pulp. Assays are given in ounces gold and silver per ton, and per cent of lead and zinc. The desired grade in the discharge lies between — 60 + 200.

*No.* 1 *Hardinge*, 6-*ft.*, 30 r.p.m. Full load of flint pebbles. Feed: oversize from small trommels in classifier line, in addition to regular proportion of jig trailing. Total 24-hour tonnage, 84.22. Solids, 43.5 per cent; water, 56.5 per cent.

*Feed.*

| Mesh | % | Gold | Silver | Lead | Zinc |
|---|---|---|---|---|---|
| + 20 | 29.69 | 0.35 | 2.3 | 1.79 | 5.48 |
| + 40 | 30.47 | 0.57 | 2.0 | 1.23 | 5.48 |
| + 60 | 16.42 | 0.62 | 2.2 | 1.41 | 7.51 |
| + 100 | 10.93 | 0.94 | 3.4 | 2.07 | 11.27 |
| + 200 | 7.81 | 0.80 | 3.5 | 4.34 | 13.61 |
| — 200 | 4.68 | 0.39 | 4.5 | 9.44 | 13.41 |

*Discharge.*

| Mesh | % | Gold | Silver | Lead | Zinc |
|---|---|---|---|---|---|
| + 40 | 11.76 | 0.80 | 2.3 | 0.94 | 3.96 |
| + 60 | 21.01 | 0.59 | 1.7 | 1.13 | 4.77 |
| + 100 | 21.85 | 0.70 | 2.4 | 1.70 | 7.21 |
| + 200 | 21.85 | 0.69 | 2.7 | 2.83 | 9.75 |
| — 200 | 23.53 | 0.64 | 3.1 | 5.38 | 9.65 |

*No.* 2 *Hardinge*, 6-*ft.*, 30 r.p.m. Poor grade of grinding pebbles picked up locally. Feed: proportion of jig tailing. Total tonnage in 24 hours, 75.5. Solids, 37.1 per cent; water, 62.9 per cent.

*Feed.*

| Mesh | % | Gold | Silver | Lead | Zinc |
|---|---|---|---|---|---|
| + 20 | 56.31 | 0.42 | 2.6 | 2.07 | 6.09 |
| + 40 | 15.54 | 0.26 | 2.7 | 1.79 | 8.94 |
| + 60 | 6.80 | 0.47 | 4.1 | 2.27 | 14.42 |
| + 100 | 7.75 | 0.43 | 3.8 | 1.89 | 16.05 |
| + 200 | 9.72 | 0.23 | 3.1 | 1.41 | 13.30 |
| — 200 | 3.88 | 0.21 | 4.7 | 5.47 | 25.25 |

*Discharge.*

| Mesh | % | Gold | Silver | Lead | Zinc |
|---|---|---|---|---|---|
| + 40 | 16.66 | 0.42 | 2.2 | 1.13 | 3.86 |
| + 60 | 14.60 | 0.52 | 2.2 | 1.04 | 5.58 |
| + 100 | 16.66 | 0.47 | 2.5 | 1.32 | 8.43 |
| + 200 | 21.87 | 0.51 | 2.6 | 1.32 | 11.07 |
| — 200 | 30.21 | 0.26 | 3.6 | 3.70 | 11.27 |

*Tube Mill*, 3½ *ft. by* 16 *ft.*, 30 r.p.m. Mixed pebbles. Feed: coarse table middlings in addition to proportion of jig tailing. Total 24-hour tonnage, 129.6. Solids, 30 per cent; water, 70 per cent.

*Feed*

| Mesh | % | Gold | Silver | Lead | Zinc |
|---|---|---|---|---|---|
| + 20 | 60.18 | 0.23 | 2.8 | 1.60 | 4.67 |
| + 40 | 14.10 | 0.26 | 2.3 | 1.51 | 7.62 |
| + 60 | 7.01 | 0.23 | 2.7 | 1.79 | 16.89 |
| + 100 | 8.77 | 0.36 | 3.5 | 1.89 | 20.05 |
| + 200 | 7.60 | 0.17 | 2.6 | 1.32 | 10.46 |
| — 200 | 2.34 | 0.31 | 5.1 | 10.58 | 14.25 |

*Discharge.*

| Mesh | % | Gold | Silver | Lead | Zinc |
|---|---|---|---|---|---|
| + 40 | 21.18 | 0.14 | 1.1 | 0.85 | 2.94 |
| + 60 | 16.47 | 0.20 | 1.4 | 0.94 | 6.30 |
| + 100 | 23.53 | 0.29 | 2.8 | 1.70 | 14.86 |
| + 200 | 23.53 | 0.24 | 2.8 | 2.07 | 14.55 |
| — 200 | 15.29 | 0.21 | 3.7 | 5.85 | 13.64 |

*Small Hardinge*, 4-*ft.*, 30 r.p.m. Mixed pebbles. Discharge end elevated 1¾ in. above the feed. Feed: jig middlings. Total 24-hour tonnage, 142.6. Solids, 18.7 per cent; water, 81.3 per cent.

*Feed.*

| Mesh | % | Gold | Silver | Lead | Zinc |
|---|---|---|---|---|---|
| + 20 | 46.34 | 0.60 | 5.2 | 17.2 | 33.6 |
| + 40 | 12.20 | 0.64 | 5.7 | 16.0 | 32.4 |
| + 60 | 7.32 | 0.36 | 4.5 | 18.7 | 22.8 |
| + 100 | 8.54 | 0.32 | 4.3 | 8.2 | 17.6 |
| + 200 | 14.63 | 0.26 | 6.0 | 9.8 | 15.0 |
| — 200 | 10.97 | 0.28 | 6.0 | 16.5 | 12.3 |

*Discharge.*

| Mesh | % | Gold | Silver | Lead | Zinc |
|---|---|---|---|---|---|
| + 60 | 2.14 | Not enough for assay. | | 7.5 | 23.2 |
| + 100 | 12.19 | 1.00 | 9.0 | 5.7 | 22.5 |
| + 200 | 34.15 | 1.24 | 5.4 | 11.0 | 26.5 |
| — 200 | 51.22 | 0.68 | 6.8 | 8.8 | 24.3 |

A noticeable feature of the analyses, particularly in the discharged pulps, is the higher grade of lead and zinc in the fine sizes, and of gold in the coarse. This suggests the possibility of undue loss in the extreme sizes: gold in coarse tailings, and base minerals in slime.

### Recovery of Free Gold and Silver

From the flow-sheet it will be seen that the pulp is run over amalgamated plates or carpets, or both, prior to table concentration. The carpet washings are dressed on a table, and the rich concentrate amalgamated in a grinding pan. Another product treated by pan amalgamation is the lead concentrate from the first four riffles of the primary Card tables treating the coarsest pulp. This part of the lead concentrate is very high grade in gold. If mixed with the product shipped to the smelter, it would tend to make sampling more difficult and settlements less satisfactory. Probably it is better to recover this gold as bullion than to run the risks attendant on sampling a "spotty" concentrate.

The following figures show the assay value in ounces per ton of the carpet washings on three consecutive days, and of the concentrate from the first four riffles of the coarse Card tables.

| | Gold | Silver |
|---|---|---|
| Carpet Washings (a)................ | 10.86 | 13.5 |
| Carpet Washings (b)................ | 18.50 | 18.5 |
| Carpet Washings (c)................ | 15.88 | 18.1 |
| Rich Card Conc...................... | 40.05 | 38.3 |

Both Wilton and Brussels carpets have been used for gold recovery, and tests have been made to establish their comparative value as gold-saving devices. Below are given the weights and assay values per ton of carpet concentrates recovered on the two kinds of carpet, under the same conditions of feed for a period of 4 hours. The superiority of Brussels is apparent.

| | Weight recovered | Gold Oz. | Silver per ton | Lead per cent. | Zinc per cent. |
|---|---|---|---|---|---|
| Wilton ........ | 16 oz. | 36.2 | 35.6 | 35.7 | 11.2 |
| Brussels ..... | 35 oz. | 83.8 | 47.2 | 48.4 | 10.5 |

### Table Concentration

Card tables were selected for use in this instance as being better adapted to the treatment of an ore containing several minerals to be separated. Deister slime tables and Monell slime vanners are used on the finest sand and slime pulps respectively. Richards pulsator classifiers of the launder type are used to classify the pulp fed to the tables on the upper floor. The flow-sheet shows similar classifiers ahead of the tables retreating middlings on the second floor; but these are not in use at present, as assays of the tailings from these tables, with and without classified feed, showed no appreciable variation. A further advantage is gained by keeping out of the system the additional water required by these classifiers.

The flow of pulp and disposition of products in this part of the mill can be comprehended better by reference to the flow-sheet than from written description.

Many tests have been made in this department, in an effort to see in what direction improvement could be made. All results seemed to point toward the possibility of an increase in mill capacity without material increase in tailing loss. This has practically been accomplished, and the plant is now treating 150 tons per day instead of the 100 for which it was designed. On one occasion, when one of the duplex wet elevators was being repaired, half of the Card and Monell tables were shut down and the entire feed diverted to the other half, thus doubling the load. This condition prevailed for 12 hours, and the tailing discharged from the mill was not appreciably different from that for the balance of the 24 hours with all tables in use. The assays are given below:

| | Gold Oz. | Silver per ton | Lead per cent. | Zinc per cent. |
|---|---|---|---|---|
| Tailing with all tables running | 0.04 | 1.5 | 1.2 | 3.8 |
| Tailings with half of tables running under double load.. | 0.03 | 1.2 | 1.5 | 4.3 |

### Losses in Various Tailings

The following tabulation of assays on tailings from the tables on the upper floor illustrates a condition already referred to, *viz.*, that the losses of precious and base metals tend to decrease and increase, respectively, the finer the ore is ground:

| Table | Classifier spigot | Gold Oz. | Silver per ton | Lead per cent. | Zinc per cent |
|---|---|---|---|---|---|
| 2 Cards ............ | 1 | 0.15 | 1.4 | 0.7 | 2.8 |
| 1 Card ............... | 2 | 0.11 | 1.0 | 0.5 | 2.1 |
| 1 Card ............... | 3 | 0.04 | 0.7 | 0.4 | 2.2 |
| 3 Deister ........... | 4 | 0.04 | 0.7 | 0.7 | 2.3 |
| 1 Card ............... | Overflow | 0.03 | 1.0 | 0.7 | 3.8 |

This condition is confirmed by many screen tests and assays on the unfinished products from various points in the concentrating system, as well as in the final mill tailing. It complicates the problem of recovery and taxes our known methods of physical concentration almost to the limit. In fact, it is such conditions as exist in this instance that urge some of our metallurgists to seek and hope for successful chemical methods of treatment. The following tabulation on the general mill tailing is added to further show the condition referred to. Assays of gold and silver are in ounces per ton, and lead and zinc in per cent.

| Mesh | % | Gold | Silver | Lead | Zinc |
|---|---|---|---|---|---|
| Original sample | | 0.07 | 2.1 | 2.4 | 4.5 |
| + 35 | 4.99 | 0.15 | 2.4 | 2.1 | 4.6 |
| + 65 | 19.11 | 0.16 | 1.5 | 1.0 | 3.1 |
| + 100 | 10.25 | 0.22 | 1.4 | 0.7 | 1.7 |
| + 200 | 24.93 | 0.09 | 1.5 | 0.8 | 1.7 |
| — 200 | 40.72 | 0.07 | 3.2 | 2.9 | 7.3 |

### Slime Concentration

The commercial value of high-grade products is well shown in the slime concentrates. The flow-sheet indicates that the concentrates from the Monell vanners are split into two products: one which is mainly galena, of sufficiently high grade to be mixed with the regular lead concentrates, and the other a mixture of pyrite, blende and silica. The latter is not a profitable commercial product, as it contains only about 30 per cent zinc and 9 per cent lead. Tests show that this material can be retreated on a Wilfley table, and separated into lead-iron and zinc concentrates which will be more valuable than the original feed. When this plan is put into effect, the Monell table will be operated so as to deliver a more silicious zinc slime, and this will be separated on the Wilfley into (a) lead concentrate, (b) zinc concentrate and (c) tailing which will be returned to the mill system. The Wilfley will be equipped with a wheel for the continuous return of its own middling.

It is by attention to such details as the foregoing that economic success is won in the concentration of complex ores. Products of high commercial value must be sought rather than those which represent primarily the greatest saving. Smelting schedules on base metals, particularly zinc, are so arranged that a difference of only a few per cent in the grade of concentrates will determine the profit or loss on the operation. The Monell zinc slime just considered brings a ridiculously low price in the market, merely because it falls below the grade desired by the smelter. Its commercial value can be considerably increased by redressing it, and the net economic recovery may be increased even though a metallurgical loss be sustained in the operation. Re-treatment of products may complicate the flow-sheet, but is justified as long as more profit can be made.

### General Mill Results

The finished products from the concentrating mill are: bullion, lead concentrates from jigs and tables, zinc-iron middlings, and Monell zinc slime. The zinc-iron middlings are treated in the electrostatic plant. Gold and silver occur in all of the mill products, as shown in the following tabulation of results for September. Lead assays are made wet:

| | Weight, tons | Gold, oz. | Silver per ton | Lead, per cent. | Zinc, per cent. | Copper, per cent. |
|---|---|---|---|---|---|---|
| Ore crushed .......... | 3989 | 0.25 | 3.1 | 5.4 | 8.7 | 0.6 |
| Lead concentrate ..... | 138 | 2.26 | 12.4 | 48.8 | 10.8 | 0.7 |
| Zinc-iron middling..... | 273 | 0.32 | 7.0 | 7.2 | 38.1 | 2.3 |
| Zinc slime ............ | 34 | 0.19 | 7.1 | 9.6 | 30.9 | 1.5 |
| Tailing ............... | ... | 0.07 | 1.7 | 1.4 | 4.0 | 0.3 |
| Amalgam: From pan, 220.6 oz.; from plates, 99.1 oz. | | | | | | |
| Saving calculated from heads and tailings ............ | | 75.9% | 50.6% | 86.7% | 58.6% | 55.0% |

### Tailings Impounded

The mill tailings are impounded in a series of terraced ponds, both because it is an unwise policy in this day to put tailings beyond possible recovery, and because it is necessary to keep them out of the streams. As far as can be seen at present the tailings have no value, but if metallurgical methods should become sufficiently improved to treat such material profitably, it will be available without great expense. Possibly when that time arrives the successful method can be applied to the crude ore with better success than now attends concentration.

### Electrostatic Separation

The Huff electrostatic system[1] is used for the separation of the zinc-iron middling into merchantable products for zinc and lead smelting. The equipment and general arrangement of the plant are shown on the flow-sheet. The capacity is approximately one ton per hour, except on a slime feed, when it falls about one-half. The ore is first dried in a wood-fired rotary kiln, consuming one cord of wood per day. The drier is lined with fire-brick. Some difficulty has been experienced in keeping the lining intact, but recently this trouble has been overcome by setting the brick in a mortar of cement and asbestos.

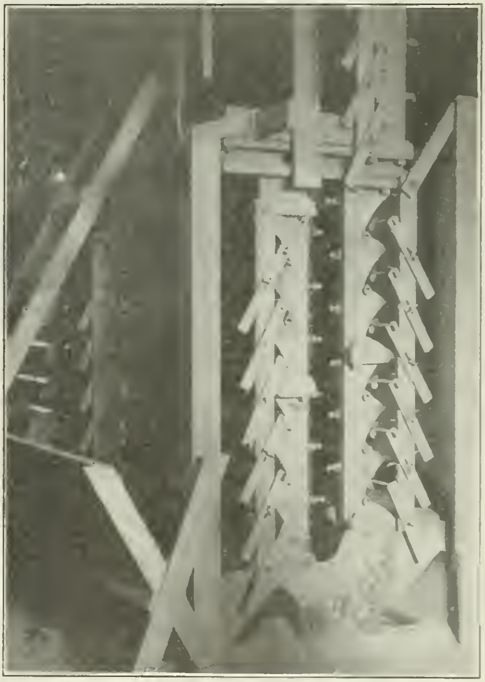


FIG. 8.—PORTION OF ELECTROSTATIC SEPARATORS

The dried pulp is separated into coarse and fine grades by a Newaygo 50-mesh screen, and the plus and minus sizes are delivered to the three Huff separators. These are of the "toboggan" type, shown in part in Fig. 8. The upper set of electrodes give a rough separation of iron from zinc, and each of these products is finished on one of the two lower sets.

A middling product results from the final separation, which requires further treatment. Several methods of handling this material have been experimented with: it has been added continuously to the original feed, and it has been accumulated and treated separately. The latter method results in a further complication: a second middling is produced which, for a curious and unexplained reason, refuses to yield a further separation either by electrostatic treatment or wet dressing. The result is a final accumulation of a comparatively worthless product.

---

[1] Descriptions of this process have appeared in this journal, May 1910, p. 295, Nov., 1910, p. 636, Jan., 1912, p. 49, Oct., 1913, p. 581.

The opinion generally maintained on the retreatment of electrostatic middling is that it should be added continuously to original feed, and this method may be finally adopted at this plant.

The flow-sheet shows electrostatic treatment of the zinc slime from the Monell vanners. The greatly reduced capacity of the electrostatic separators on this fine material, combined with the unsatisfactory results obtained in regard to grade of product, has led to the discontinuance of this practice.

FIG. 9.—SLIME SETTLING PONDS

As stated before, an effort will be made to beneficiate the Monell slime by a retreatment on a Wilfley table.

The following results are typical of the electrostatic work done on different feeds:

*Table Middlings.*

| | Gold | Silver | Lead | Zinc | Copper | Iron |
|---|---|---|---|---|---|---|
| Feed ... .... | 0.40 | 6.8 | 7.2 | 35.9 | 2.6 | 10.8 |
| Zinc product.. | 0.40 | 5.2 | 5.6 | 47.2 | 0.9 | 5.2 |
| Iron product | 0.41 | 8.6 | 9.8 | 15.2 | 5.1 | 24.2 |
| | | | | | | |
| Feed ..... ... | 0.42 | 6.1 | 7.6 | 37.8 | 1.3 | 10.7 |
| Zinc product... | 0.24 | 5.1 | 5.0 | 51.8 | 0.6 | 3.8 |
| Iron product.. | 0.52 | 9.1 | 10.3 | 17.8 | 2.5 | 23.0 |

*Retreatment of Electrostatic Middlings.*

| | Gold | Silver | Lead | Zinc | Copper | Iron |
|---|---|---|---|---|---|---|
| Feed | 0.52 | 9.1 | 10.2 | 28.2 | 1.4 | 14.0 |
| Zinc product | 0.56 | 9.8 | 11.1 | 34.8 | 0.7 | 9.4 |
| Iron product | 0.62 | 9.9 | 9.0 | 12.8 | 5.0 | 26.8 |

*Monell Zinc Slime.*

| | Gold | Silver | Lead | Zinc | Copper | Iron |
|---|---|---|---|---|---|---|
| Feed | 0.22 | 6.8 | 8.8 | 31.0 | 1.6 | 10.0 |
| Zinc product | 0.34 | 6.1 | 11.9 | 34.2 | 1.6 | 8.5 |
| Iron product | 0.52 | 10.0 | 8.7 | 16.1 | 5.0 | 22.1 |

The dust formed in the process of drying the middlings appears to be inconsiderable, amounting to only two tons in four months. Ninety-two per cent of it is finer than 200-mesh.

It assays 0.32 oz. gold and 9.9 oz. silver per ton, 8.0 per cent lead, 24.5 per cent zinc, 3.9 per cent copper and 8.5 per cent iron.

It is practically without commercial value, and would be a difficult material to treat by wet or dry methods of concentration.

In conclusion the writer wishes to express his appreciation of the courtesy of Mr. George E. Collins, general manager, and members of his staff, for the facilities offered in collecting these notes.

# Chemistry of Salt Water Cement

## Notes on Sand, Stone and Gravel

BY HARRISON S. TAFT

1. The success to be attained by placing concrete structures in sea water depends upon, first, the possibility of using cement in salt water, and, second, an economical design. Without doubt a great many prominent engineers hesitate to recommend the placing of concrete structures in sea water more from a chemical point of view perhaps than from a structural one. If the material out of which the structure is to be built cannot be depended upon to maintain its integrity when exposed to the elements, the very best design will not solve the problem.

Therefore the chemistry and manufacturing side of the cement industry becomes a question of prime and vital importance as regards cement to be used in sea water structures. The next question is that of impermeability; otherwise the concrete might slowly deteriorate under the action of the chemicals in sea water, since perhaps it is impossible to reduce such actions to a negative quantity. In freezing climates this question of impermeability becomes a very serious one, due to the destructive action of alternate freezing and thawing.

2. **Cement.**—The first and chief difficulty that has to be overcome in using concrete in sea water is "the peculiar chemical disintegrating action of the magnesium and other sulphate contents of ocean water upon the alumina compounds in the cement," followed "by the abrasive action of the water of the ever-restless sea" upon the chemically affected and softened concrete.

To overcome the chemical action of the sea water upon concrete the Germans have placed upon the market a brand of cement called "iron ore cement," wherein the alumina content of a cement is partly replaced for fluxing purposes by iron which is not affected deleteriously by the magnesium and other sulphates of the salt water; thus inoculating the concrete, as it were, against attack. The world-famed Teil Cement Works does not allow more than 2 per cent alumina and absolutely no free lime in the cement which they manufacture for use in concrete structures standing in sea water.

Another German product called Puzzolan-Portland Cement, especially devised for use in sea water, has been on the market some 16 to 18 years. This product is a mixture of Portland cement and a natural puzzolan (a volcanic ash), or of a Portland cement and an artificial puzzolan (blast furnace slag of a certain chemical composition), the mixture being 30 to 60 per cent puzzolan and 50 to 70 per cent Portland cement.

The chemical action in hardening results in a Puzzolan-Portland hydraulic cement invulnerable to sea water. Although the mixing can be done on the job, it is far preferable to pulverize the two ingredients together in the mill at the cement factory.

A set of extensive tests made by the German government shows higher strength for Puzzolan-Portland cement concrete both in tension and compression than for pure Portland cement concrete. It has also been demonstrated that the former resists salt water far better than the latter. From an economic point of view in producing resistance to the action of sea water a barrel of Puzzolan-Portland cement has been found to be equal to two barrels of pure Portland cement.

From information obtained in regard to these two German cement products, concrete made of them and placed in salt water has been giving the best and most satisfactory results. Thus a vast amount of salt water concrete construction is being carried on in Germany and other foreign countries, due no doubt to their overcoming the action between salt water and the cement.

Though there have been a number of disastrous disintegrations in using American Portland cements in salt water, on the whole American Portland cement seems to have worked quite satisfactorily in sea water.

Such cement "has the power of armoring itself against the action of the magnesium sulphates of the sea water by the formation on its exposed surfaces of a film of lime carbonate." This film appears to serve as an effective protection to the concrete structure in comparatively still waters, but where the waters are greatly agitated this film has no opportunity to form. Hence "the calcium hydrate set free by the decomposition incident to the hardening of the Portland cement is washed away," leaving the concrete stucture unprotected against "further inroads of the deleterious chemicals contained in the sea water."

To reduce the question of the chemistry of sea water cement to a more technical form:[1] "The magnesium sulphate present in sea water acts upon the calcium hydrate of the cement, forming calcium sulphate, and further, this calcium sulphate combines with the alumina of the cement, forming calcium sulpho-aluminate, which last compound gives rise to the swelling and cracking of the concrete."

Mr. O'Hara also states that though it may seem that a cement in which the alumina has been replaced by iron is desirable, it would be impracticable, however, to replace *all* the alumina in a cement by iron oxide, as "a product resulting from the burning of ferric oxide and calcium carbonate does not possess hydraulic properties." He further says that whereas it seems to be universally accepted by engineers and others that a dense concrete is impermeable to sea water, the results of tests made by him do not seem to bear out this theory, unless the cement used has the inherent qualities to resist the disintegrating action of the sea water.

In discussing the subject of mass concrete in block form for breakwater purposes, William Matthews, a prominent English engineer, says:

"In a tideway, where mass concrete is used, it is of the utmost importance that the relative sizes and proportions of the aggregate should be such as to produce an absolutely water-tight material. The infiltration of sea water into green or unset concrete and its subsequent exudation due to tidal action causes the magnesium salts in the sea water to withdraw a portion of the lime of the cement in the form of calcium salts, leaving a deposit of magnesia in its place. It is this magnesia, derived from sea water, either alone or mixed with lime from the cement, which constitutes the white substance deposited in the interstices of porous concrete between high and low water. Concrete so affected possesses but little strength and its failure is only a question of time."

As the result of his research upon the use of cement for sea water purposes, the eminent Dutch chemist, V. I. P. de Blocq van Kuffeler, Hoorn, states[2] "that the decomposition of the concrete is caused by the salts contained in sea water; the sulphates are the most to be feared owing to their action on the unstable compounds of lime which are formed during the very long period taken by the cement for hardening. Evidently it is during the first part of this period that the action of sea water is the most detrimental, i.e. when the compounds are least stable. Actual experience has confirmed this theory."

He also says that "when such material as trass or puzzolanes are added to the cement, one part of the lime forms compounds with silicates, the other compounds mentioned becoming more stable and the influence of sea water is less to be feared"; that "fine trass increases the impermeability of the mortar"; and "if the concrete has been hardened in a damp atmosphere the influence of the trass is still more marked."

Irrespective of the brand, a cement to be successfully used in salt water must be of the very best quality, of a fine pulverization, and thoroughly analyzed and tested for its chemical properties. Every means should be taken to avoid too much alumina in a cement that is to be used in salt water. The per cent of alumina should be low, that of silica high. The cement should also be as free as possible from gypsum.

A cement of the slow hardening order should be avoided. Distinction between "setting" and "hardening" of cement should be kept in mind. A slow setting but quick hardening cement is the proper kind to use in salt water.

Not only must the cement manufacturers provide the engineer and the contractor with a cement of the proper chemical constituents, but the concrete made from said cement must be dense in order to fulfill all the requirements of a salt water concrete. This apparently is what the Germans have been doing, and it explains why they are able to get such excellent results in concrete work in Germany as well as in other foreign countries. It is an exceedingly important question for domestic cement manufacturers to consider.

As considerable stress has been laid above on the German method of manufacturing cement for sea water purposes, it is fitting to still further consider what Herr Blocq van Kuffeler says upon the question of using cement in concrete placed in salt water. He states that the following points should be most strictly adhered to in using concrete in salt water:

(a) Artificial (slow-setting Portland) cement of first-class quality and hardening very uniformly, should be used to the exclusion of all others.

(b) The mixing of the material and the ramming of the concrete in strong and tight casings must be performed with the greatest possible care.

(c) The use of trass (or puzzolanes) is recommended.

(d) The concrete must be compact and the composition of the mortar should not be below 1 part cement, ½ trass and 3 sand, or I part cement, 1½ sand.

(e) Allowing the concrete to set in a damp atmosphere before placing "in situ" greatly increases its resistance to attack by sea water and is recommended where possible. When the concrete is exposed to the infiltrations of sea water immediately after manufacturing its composition should be richer.

In conclusion he says a carefully considered composition, most careful manufacture, the use of excellent cement with trass (or puzzolan) and hardening in a damp atmosphere are the most efficient means of satisfactorily ensuring the preservation of reinforced concrete in maritime works.

**3. Laboratory or Similar Tests.**—For several years past the United States Government has been carrying on a set of tests at Atlantic City and elsewhere to determine the exact fact as regards the use of cement in sea water. A preliminary report of these tests has recently been issued by the Government. Although three years is a comparatively short time for determining the absolute facts under actual conditions, the results of these tests so far published seem to indicate that the success of using concrete in sea water depends in a large degree upon careful and proper working of the material rather than upon the special brand of the cement itself. It is true that some cement works better than others in sea water, those with a low percentage of alumina giving the most satisfactory results, but with an impermeable structure as the prime factor in all cases.

Although these Government tests will no doubt in time give the concrete engineer the absolute facts as regards the situation, the engineers of this country already have the actual experience of some 18 years of foreign practice by which to guide themselves. No doubt the final results of these United States Government tests will simply substantiate what has already been learned regarding the use of cement in sea water by foreign chemists, viz.: an *impermeable mass* with a low per cent of alumina in the cement used.

---

[1] From Report of J. M. O'Hara, Southern Pacific Railway.

[2] From a paper read before International Association for Testing Materials, New York, September, 1912

In the early part of 1909 twenty-four test pieces were made of concrete and hung from one of the wharves at the Charlestown Navy Yard, Boston Harbor. These test pieces were 16 feet long, 16 inches square and made with a core for part of their length so as to provide a means of determing their permeability. Several different kinds of cement were used in making these pieces and the concrete mixed in various proportions; some of the pieces being made dense, others porous. These pieces were hung from the pier in such a way as to have their lower ends always in water, while the tops were seldom submerged. At the end of the first two years of immersion one of these test pieces showed marked signs of deterioration, while others were in good condition. Later reports go to substantiate the truism mentioned above, since the pieces made of a porous nature have deteriorated somewhat while those of a dense nature are in the same perfect condition as the day they were made.

Though these laboratory tests will go a long way in revealing the true facts and actual conditions it is necessary to guard against in the use of cement in sea water, "it must ever be kept in mind that the phenomena, both physical and chemical, in the sea cannot be reproduced exactly in laboratories on land." Consequently laboratory tests will never give the real truths of using cement, and hence concrete, in sea water as will actual experience. Thus the actual experience of foreign engineers in the use of concrete in sea water structures and the modes pursued by them are far more valuable to the American engineer than any short time test made in this country.

Admitting that laboratory tests are absolutely necessary and that the world cannot get along without them, such tests must be considered hand in hand with actual experience and as supplementary thereto. The fact that local conditions and local material will seriously alter cases brings home to the engineer the truth that he must not judge foreign experience by home conditions, and vice versa, until the actual conditions covering each are known and is used as the complement of the other.

**4. Waterproofing Compounds.**—In view of the claims made by waterproofing experts as respects the excellency of their product, it is proper to quote from an article entitled "Test of Water-Proofing Material," U. S. Bureau of Standards, No. 3, August 22, 1911: "Portland cement mortar and concrete can be made practically water-tight or impermeable (as defined below) to any hydrostatic head up to 40 feet, without the use of any so-called 'integral' water-proofing material; but in order to obtain such impermeable mortar or concrete, considerable care should be exercised in selecting good material and aggregate, and proportioning them in such a manner as to obtain a dense mixture. The consistency of the mixture should be wet enough so that it can be puddled, the particles flowing into position without tamping. The mixture should be well spaded against the forms when placed so as to avoid a formation of pockets on the surface."

"The addition of so-called 'integral' waterproofing compounds will not compensate for lean mixtures, nor for poor material, nor for poor workmanship in the fabrication of the concrete. Since in practice the inert integral compounds (acting simply as void filling material[1] OR IN THE NATURE OF A LUBRICATING MATERIAL) are added in such small quantities, they have little or no effect on the permeability of the concrete. If the same care is taken to make the concrete impermeable, without the addition of waterproofing material, as is ordinarily taken when waterproofing materials are added, an impermeable concrete can be obtained."

In connection with this part of the subject it may not be out of place to speak of "oiled concrete" for waterproofing certain classes of concrete structures. It is of such recent development that sufficient opportunity has not been given to determine its real merits for universal waterproofing purposes especially as regard concrete structures standing in sea water. So far as known there are no records "of any such tests ever having been made" and some chemists have positively stated that it will be impossible to make oiled concrete a success for sea water purposes.

On the other hand, I. Hiroi, a civil engineer of Japan, has stated: "Of more than 12,000 concrete blocks of all sizes and of different compositions, used by the writer in harbor works during the past ten years, there has not been the slightest indication of failure. On the contrary, the protection given by coatings of animal, vegetable and mineral origin to the surfaces of the blocks has rendered them almost impregnable against the incessant action of the sea. The protection thus afforded by nature, which would render a comparatively weak artificial stone, when properly made, as lasting as the natural stone used as its ingredient, is unknown in laboratory experiments."

**5. Sand, Gravel, Stone.**—The sand used in concrete placed in sea water must be clean, sharp and free from all foreign material. The stone must also be clean and sound. Gravel, if used, must likewise be clean and of proper size. The chemical composition and mineral structure of the stone, sand and gravel for use in proposed sea water concrete structures, should be known absolutely beyond all doubt. Since it is of great importance that concrete used in sea water should have the maximum density, the mechanical composition of sand and gravel should be known and modified, if necessary, by adding screened material.

For the same reason that an igneous rock or material is far better in the construction of a fireproof concrete structure, it is absolutely necessary in salt water concrete to use aggregates that will not disintegrate or fail when exposed to the elements of the salt water and the action of the sea.

The eminent expert, Mr. John R. Freeman, has called the attention of engineers to the fact that "here and there are banks of sand and gravel which, upon ordinary inspection, appear ideally perfect for making mortar and concrete, but which are nevertheless dangerous in the extreme, and all because of some ultramicroscopic content, probably similar to tannic acid (in a colloidal film around the sand grain), which works in some mysterious way to prevent the union between the cement and the sand grains."

Mr. Freeman cites an occasion where he found the site of a proposed structure what promised to be a most economical resource in a shape of excellent sand and gravel; but upon being tested some of the samples of 1:3 mix, six days in water, hardly maintained their integrity while being placed in the clamps and before any load was applied. The cement was of a brand that had given excelleat results with other aggregates.

E. E. Free, an investigator, engaged upon physical and chemical investigations for the Bureau of Soils, has noticed analogous phenomena in studying the relative fertility of different soils. Mr. Free states that:

---

[1] The portion in capital letters inserted by writer

"In popular terms the situation can perhaps best be explained by considering that an extremely thin film of a complex form of tannic acid surrounds each grain of the troublesome sand and prevents its attachment to the cement. These complex organic acids have a strong tendency to spread themselves thinly and strongly adherent over the outside of the siliceous material. The reason why one particular brand of cement is able to break through this filmy barrier so as to get a firm grip upon the sand grain is because of its containing a small quantity of some form of alkali that unites with this acid film or somehow changes its colloidal state."

It is admitted that these defective sands are the exception rather than the rule. Though some engineers and contractors may think the whole investigation a highly interesting laboratory amusement, of no value whatsoever to practical construction, the fact remains that there are sands whose availability for concrete aggregate cannot be predicted under any of the ordinary methods now in vogue, and that every so often one of these sands gets into a structure to its detriment and perhaps failure if the structure stands in sea water. Therefore the sand and stone should be tested as carefully as the cement for salt water purposes.

Of equal importance is the utmost care that must be taken in mixing and placing the concrete, in order to obtain an impermeable mass throughout. Superintendents and concrete foremen should also be careful to see that injurious acids do not get into the sand, gravel and stone of concrete to be placed in sea water by the working force urinating upon the material.[4] Great care should likewise be taken to exclude from all material entering into the manufacture of concrete such things as scraps from lunches, tobacco and the spittle of those chewing tobacco. It is known that an amount of sugar, even as small as ¼ per cent will entirely prevent a batch of cement from hardening. Since the extract from chewing tobacco contains sugar or glucose, any such extract that enters into the concrete will prevent the cement from setting. There are other organic compounds whose presence in the concrete will have a marked effect on the hardening of the cement, and the utmost means should be taken to exclude such detrimental material from all concrete to be placed in sea water.

6. **Mixture.**—In connection with the concrete dock work of the Thames River the practice seems to have been to use "a gravel of moderate size combined with two-thirds of its bulk of sand mixed with one part of cement to every two parts of sand," viz., a 1-2-3 mixture. It is stated that with such a mixture there will be no fear of the results if the concrete is *properly mixed and handled.* The concrete is also given a grout coating after it has set and hardened.

In building concrete breakwaters in Holland it has been found that mass concrete blocks made of 1 part Portland cement, ½ part trass (the trass being a Puzzoland which is found near Andernach on the Rhine), 3 parts sand and 5 parts Rhine gravel, enabled the blocks to resist the corroding action of the sea water. Of more recent date they have been using a cement-trass-concrete of 1 part cement, 1-3 part trass, 2 parts sand and 3 2-3 parts gravel.

In Germany a mixture of 1 part cement, ½ part trass, 3 parts sand, 4 parts gravel, is very often used.

During recent years a very rich mixture, viz., 1-1½-3, has been used in nearly all the important sea water concrete structures built in England and France.

In the harbor development of Otaru, Japan, a proportion of 1 part cement to 2 parts sand for the mortar gave superior results; the average concrete mixture used being "1 cement, 2 sand, 2 gravel and 2 broken stone, before the tuff was put in; the ratio equivalent by weight of the cement to the tuff being, 1 cement to ½ tuff." By volume this combination reduces to:

1.0 cement; 0.8 tuff; 3.2 sand; 6.4 ballast.

In the Netherlands Portland cement concrete with the addition of trass has been used almost exclusively. Though Herr Blocq van Kuffeler recommends a mortar of 1 part cement, ½ part trass and 3 parts sand mixture for sea water structures, he states that concrete of the above composition will remain in a perfect state of preservation "provided it has been hardened in a damp atmosphere before placing *in situ*, but is apt to give disappointment if the concrete is exposed to the infiltration of the sea water immediately following manufacture." Under the latter conditions he recommends a richer composition—at least 1 part cement, ½ part trass, 2½ parts sand. When no trass is used he says a mixture of 1 part cement, 1½ parts sand should be used. He also says that whereas mortars of 1 cement, 1½ sand and of 1 cement, 1½ trass, 3 sand can be used with safety in marine concrete work, the latter will create a saving in cost of considerable extent. It is also of great importance that the cement and the trass should be thoroughly mixed before the sand is added.

As respects the use of salt water in the manufacture of concrete, the same eminent chemist states that since the amount of salts introduced into the concrete by diffusion when the concrete is exposed to sea water is vastly in excess of any salts that might be introduced into the concrete "by the small quantity of water used in its manufacture—the use of salt water in the making of concrete is in all probability prejudicial to only a slight extent."

As in ordinary reinforcement work, when the reinforcement is complicated, a smaller size gravel should be used with their homogeneity increased, a size of not over .116 cubic inch being recommended by a leading authority for marine reinforced concrete.

Mr. I. W. Sandeman, in his paper upon "Action of Salt Water Upon Concrete," states that for salt water purposes the maximum proportion of the sand in the mortar must not be more than twice that of the cement, and the mortar must exceed the voids in the aggregate. The exact grade of the sand mixed with the cement plays an important part in obtaining impermeable concrete, a hard, coarse sand giving the best results. It was the knowledge of this important point and a thorough investigation of it that enabled the noted Italian engineer, Com. Luigi Luiggi, to construct a dry dock at Bahia Blanca, in 1902, that resulted in a perfectly water-tight job. The utmost care was taken in the construction of this dock, with special attention to the bonding of old concrete to the new.

As respects the advantages of using crushed stone over gravel, Mr. Staniford, chief engineer of the New York Dock and Ferry Department, states that his department does not find gravel a suitable material to use in mass concrete when subject to the action of sea water, and that the broken, hard trap rock, so commonly used in New York City and vicinity, gives far better results in such kinds of concrete than are obtained with gravel. From the author's own experience with broken stone and gravel, he prefers stone, especially if it is trap rock.

7. **Conclusion.**—In the final analysis, the successful use of cement in concrete structures standing in sea water boils down to the use of an impermeable concrete made of a cement low in alumina and otherwise suit-

---

[4] Notes from a paper to be published by Chas. A. Newhall. By permission.

able for salt water purposes. The former is the problem of the concrete and construction engineer; the latter the problem of the chemist and cement manufacturer. To obtain an impermeable concrete a very rich mixture must be used, the exact proportion between the finer and coarser material being dependent upon the per cent of voids.

If possible the concrete should be hardened in a damp atmosphere in order to assist the chemical reaction of setting before being placed *in situ*, or before being subject to the action of the sea water, especially so if the sections are small.

The mixing and placing should be closely watched and done with the greatest care, far more so than in the ordinary building work, in order to ensure that each particle of the sand and coarser material is well covered with cement and mortar respectively. A concrete of a medium or plastic consistency will ensure far better results than a wet or dry mixture.

"In the Netherlands experience has furnished conclusive examples as a guide for future construction, with a sufficient degree of safety, as to justify the further application of reinforced concrete in marine structures, which after all are only the work of mortals and not destined to last for eternity."

*Seattle, Washington.*

## Color Photography Applied to the Demonstration of the Microstructure of Ores

Mr. Gilbert Rigg, research engineer of the New Jersey Zinc Company, presented at the meeting of the New York section of the American Electrochemical Society, on October 17, 1913, a brief but exceedingly interesting lecture on the application of color photography to the elucidation of ore structure.

As mentioned in our report of this meeting in our November, 1913, issue (page 622), Mr. Rigg has been the first to apply color photography for this purpose. At that meeting he exhibited a striking series of Lumiere plates showing photomicrographs of ores, with resolution of the minerals present. While for mechanical reasons it is impossible for us to reproduce here these pictures, we are glad to give herewith an outline of Mr. Rigg's remarks made in connection with his demonstration.

While microscopic examination of thin slices of ores furnishes valuable indications as to their structure and to their probable behavior in the mill, this method requires the services of a man trained in the work. To get the results in such form that they can be readily understood and appreciated by the mill engineer and the mill foreman has not been an easy matter.

Plain microphotographs, depending only on differences of light and shade, are not easy to interpret by men not familiar with microscopic investigation, and in many cases the presence of a competent expert, provided with suitable equipment, is out of the question.

The Lumiere plate provides a means by which the indications of the microscope can be reproduced in their natural colors. Such matters as the fineness of the constituents of the ore, the shape of the different minerals, the manner in which they are interlocked, the nature of the gangue minerals and other particulars having a direct bearing on the problem of concentration, can be brought out in a manner which is both striking and instructive.

The slides shown by Mr. Rigg were intended to illustrate certain associations of minerals which are of importance as affecting the recovery in concentration.

Adhesion of valuable minerals to the gangue was shown by a slide representing a mica-schist carrying thin, wedge-shaped particles of blende and chalcopyrite intercalated between the plates of mica. On crushing, the valuable sulphides remained attached to the plates of mica and were carried by them into the tailings.

Losses due to parasitic inclusions were illustrated by a slice of actinolite rock, carrying blende as an interstitial mineral between the actinolite crystals, and quite capable of recovery, and also as parasitic crystals inside the actinolite crystals, and therefore destined to accompany the latter into the gangue.

An example of trouble due to fineness of grain was shown by a slide of calcite, permeated by hair-cracks and fine fissures filled with blende. The difference between the assay and the mill recovery with an ore of this type would be very great.

The application of polarized light to the demonstration of the constituents of an ore was illustrated by two slides of a calcite-willemite ore, one taken in ordinary light and the other in polarized light. The former simply showed an aggregate of colorless crystalline grains. The latter showed the calcite as various shades of grey, and the willemite in brilliant blues and pinks.

The contrast between examination of a hand specimen by the unaided eye and the indications of the microscope was shown by a specimen of argentite.

The hand specimen appeared to be solid argentite. The microscope showed a series of fine lamellæ of argentite and quartz. An ore of this kind would give a disappointing assay.

### Copper-Rich Kalchoids

A word unusual in scientific nomenclature is used by Prof. Samuel L. Hoyt in the title of his paper "On the Copper-Rich Kalchoids," read at the recent meeting of the British Institute of Metals. But kalchoids is a useful "omnibus" word, being employed to designate the ternary alloys of copper, tin and zinc as was first suggested by Thurston, and as such its use should extend.

In the paper under discussion Professor Hoyt gives the results of a prolonged research into the constitution of certain kalchoids rich in copper, the percentage of zinc and of tin never exceeding 50 and 30 respectively. From his microscopical analyses—and the paper is very liberally illustrated with upwards of 40 photo-micrographs in plate form—Professor Hoyt draws the general conclusion that the ternary alloys of copper-tin-zinc, up to the above-mentioned percentages, behave similarly to the binary alloys of copper-tin and copper-zinc. The liquidous surfaces, the limit of saturation of the alpha solid solution and the eutectoid line have been determined. The eutectoid surface was found to have a maximum near the middle corresponding to 66 per cent copper, 17 per cent tin, 17 per cent zinc and 590 deg. C. on the eutectoid line. This line showed the beta solid solutions to be isomorphous. Quenching from this line produced homogeneous solid solutions. The addition of tin to the copper-zinc alloys, or brasses, caused the visible breakdown of the beta solid solution. The amount of the tin necessary varied with the zinc content and with the rate of cooling through the critical range, thereby giving rise to abnormalities in the microstructure which are explained and well illustrated in the paper. An interesting point is that Professor Hoyt records the finding of a field off the alpha plus beta range in the bronzes in which two heating effects in the solid were observed.

The research is also noteworthy as showing the world-wide interest in the work of the (British) Institute of Metals, seeing that the paper has been prepared by a professor in the American University of Minnesota, who made his investigations in the Charlottenburg-Berlin Institute of Technology.

# A New High-Temperature Furnace

BY EDWIN F. NORTHRUP

For over two and a half years the writer has been conducting an experimental research upon the electrical conductivity of matter over a wide range of temperature above 0 deg. C. He early learned that the limit of his upper temperatures was greatly restricted if any furnace upon the market was to be used. It is true that vacuum furnaces of the Arsem type give as high temperatures as may be needed. But for the work in hand a very large furnace of this kind would be required to give a temperature of the necessary uniformity over a considerable length of the tubular space, and, furthermore, the difficulties in the way of feeding metal into the furnace and of bringing many leads out of a vacuum furnace were not easy to surmount. Furnaces operated with a hydrogen atmosphere to preserve the molybdenum or tungsten wire used as a winding from oxidation are unsuitable because hydrogen acts upon many of the molten metals. He was obliged, therefore, to develop a new and special type of furnace for the satisfactory prosecution of his research. This new type of furnace has had a development which has lasted over six months and it is now in a highly satisfactory state.

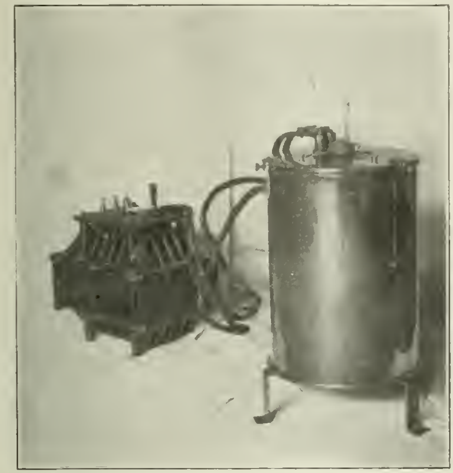


FIG. 1.—FURNACE AND TRANSFORMER

It is a laboratory furnace of the tubular type and is required to meet, in a very perfect way, the following conditions:

It must give a very uniform temperature in a tubular space about 12 in. long by 1⅞ in. in diameter.

The furnace must run for several hours above the melting point of platinum (1755 deg. C.) without being rapidly deteriorated.

The hot tubular zone must develop a pure CO atmosphere and the heating unit not be injured by the vapors of any molten metal or other material placed in the tubular space.

It is desirable and almost essential that all parts of the furnace, including the heating unit, should be quickly and easily replaceable. The life of the heating unit should be such that the expense for new heating units is not excessive.

It is evident that the one material for a heating unit which gives most promise of meeting these conditions is some form of carbon. The form of carbon adopted is pure Acheson graphite. This material has a low though very constant resistivity. As pointed out in a former article[*] its resistivity decreases about 9 or 10 per cent in the temperature range 20 deg. to 1500 deg. C. and not rapidly thereafter. There is probably no other material that has so constant a resistivity over so great a range of temperature. The resistivity being low, it is evident that the current must travel through a long length of the material and through a small cross section in order that the total resistance of the furnace may be sufficiently high to permit the use of relatively small currents. The furnace as made has a resistance when cold of 0.14 ohm. This result is obtained by the special manner in which the graphite heater-tube is cut. Furthermore the cuts are made in such a manner that the extreme ends of the tube develop exactly as much heat as the middle portion, and this permits great uniformity in the heating over a long length of tubular space. Such a tube when cut, if not properly protected, would be fragile mechanically and means had to be devised to make the heater-unit as a whole mechanically robust. This result is attained in a very effectual manner by carefully worked out details in the construction.

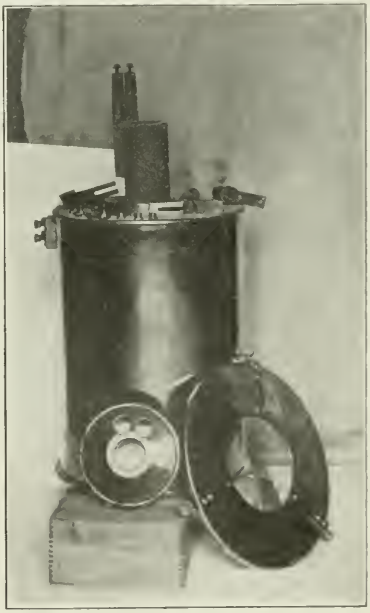


FIG. 2.—REMOVING A UNIT

Carbon or graphite, as is well known, is readily attacked by oxygen when above a red heat, and it was recognized that, if a unit were to last for many heatings, say forty or fifty, it must be effectually protected from oxidation. Perhaps the accomplishment of this result, without making use of a vacuum or by passing through the furnace any protecting gas, presented the greatest difficulty and expense. An electric furnace can only be thoroughly tested by destroying it, in which respect it is like a skyrocket. The result was finally attained by mounting the heater-unit in a molded refractory surrounded by what amounts to a hermetically sealed casing of monel metal. The CO atmosphere is developed by graphite. *which is not a part of the re-*

---

[*] "Some Effects of Temperature Upon the Resistance of Graphite and Carbon," METALLURGICAL AND CHEMICAL ENGINEERING, May, 1913.

*sistor*, and soon fills the furnace and effectually protects the graphite heater-unit for continued heating.

The terminals, which are always supposed to give trouble in furnaces which take a large current to operate, give no trouble and have a life longer than the unit itself. The furnace stands vertical and the two terminals project from the upper end of the tube at one side. They are covered with metal caps which can be quickly and easily removed.

The refractories in the furnace were selected, after much experimentation, to withstand a temperature of over 1800 deg. C. and to give at the same time the highest possible thermal insulation.

The tubular space in the furnace, which can be utilized for heating purposes, is 12 in. long by 1⅞ in. in diameter. The furnace casing is cylindrical in form and is made of monel metal, polished. It is 18¼ in. in length and 13 in. in diameter, on three legs 4½ in. high.

The furnace is so designed that in less than five minutes a graphite heater-unit can be withdrawn from the top of the case and a new one substituted. The metal terminal-caps, the refractories in the interior of the case and the top refractory piece, which forms the central portion of the top of the furnace, are all standard in size and easily and quickly interchangeable. In fact, perfect and easy interchangeability of all parts of the furnace is one of its special features.

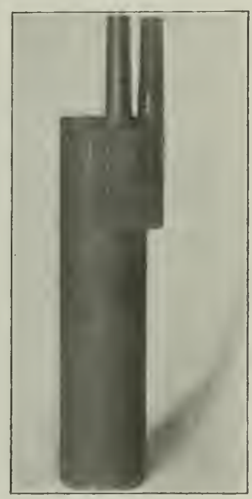


FIG. 3.—HEATER-UNIT

This furnace will operate, of course, on either direct or alternating current and calls for a maximum of 170 amp. at 23 volts. It is preferable to operate the furnace with a transformer of 4 kw capacity and such a transformer is a part of the outfit. The regulation of temperature is accomplished by the kilowatt input and this is varied by means of a switch which throws into circuit a varying number of turns upon the primary of the transformer. All the heat, therefore, is developed in the furnace where it is wanted instead of in rheostats where it is not wanted.

*The furnace cannot be burned out* with the transformer which is supplied with it. The heater-unit after repeated heatings will in time begin to gradually grow higher in resistance and when this resistance has become so great that with the 23 volts furnished by the transformer the required high temperature cannot be obtained, the old unit must be replaced by a new one. The writer cannot state definitely the life of one of these units, because this depends so largely upon the maximum temperature at which the furnace is operated. He believes, however, that it is a conservative statement to say that a unit may be heated to a temperature of 1500 deg. C forty or fifty times, and perhaps oftener. All other parts of the furnace are practically indestructible. He has had great satisfaction in using this furnace in feeling absolutely assured that in the midst of an important measurement the furnace will not burn out or otherwise fail to operate. Also, that nothing that he may put in the furnace, in the way of metal vapors, etc., will in any way injure it.

By the manner in which this furnace is constructed the heat insulation is the most perfect possible and the high temperatures reached are attained rather by a slow accumulation of heat, which only in part escapes as it is being developed, than by a brief and rapid input of a large amount of energy. In fact, a furnace may be constructed with very little heat insulation and a very high temperature be attained quickly with large power input, or it may be constructed with a large amount of heat insulation and the same high temperature be attained by the input of a small amount of power continued over a long time. For some classes of work the former and for other classes of work the latter type of furnace best serves the purpose. This furnace is of the latter type and consequently the watt input required to bring it to a high temperature is very small considering the size of the heating space, but this small watt input must be continued for a considerable time before the high temperature is reached. The furnace heats very slowly and cools very slowly. Slow cooling, for the work being done by the writer was desirable. The performance of the furnace in respect to rate of heating was measured several times and the accompanying curve gives a very good idea of how the furnace performs in respect to rate of heating.

The size of the furnace is that required by the writer in his work, but there is no reason why, with the same construction, the size may not be increased or decreased and the mounting be made horizontal as well as vertical.

The bottom of the tube when containing a crucible gives a perfect black body temperature and this makes the furnace admirably suited to the calibration of optical pyrometers.

Though this furnace was developed for his own researches it became apparent that it is so extremely useful for laboratory investigations that arrangements are being effected for its sale through the agency of the Arthur H. Thomas Company, of Philadelphia. The cost of development was large and no pains have been spared to perfect the furnace in workmanship and in minutest detail, and to use the best materials obtainable for its construction. The polished monel metal case makes the furnace a handsome and cleanly piece of laboratory apparatus. The outside of this case never exceeds 200 deg. C. when the interior of the furnace is at the temperature of melting platinum. It will not be an inexpensive piece of apparatus, but it is hoped a very useful one for

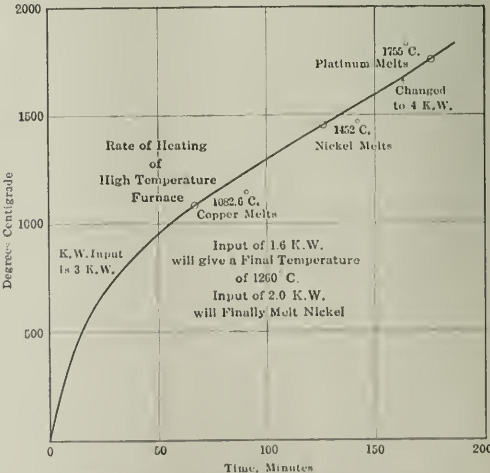


FIG. 4.—RESULTS OF TEST OF ELECTRIC FURNACE

those who have problems to solve in the temperature range 1000 deg. to 1700 deg. or possibly 1800 deg. C.

*Palmer Physical Laboratory,*
*Princeton, N. J.*

---

# Notes on Chemistry and Metallurgy in Great Britain

*(By Our London Correspondent)*

### The Institution of Electrical Engineers

### Research Announcements

The Research Committee of the Institution has announced its intention of conducting extensive investigations into questions concerning the nature and properties of insulating oils and of magnet steels. With regard to switch and transformer oils the subjects of research are classified as chemical, physical and chemico-physical.

In the chemical sections the questions arising include the relations between temperature and formation of sludge with exposure to the atmosphere; the laboratory tests to determine the production of sludge under abnormal conditions; and the means of preventing the formation of sludge; the absorption of moisture at various temperatures and the laying down of a standard as to what constitutes a dry oil, and what effect on specific resistance and dielectric strength is produced by increase of moisture; the investigation of the comparability of results obtained by the usual tests for acid, alkali, sulphur, resin and other impurities, and the standardization of such tests; the composition of the gases liberated when an arc is formed in the oil; the nature of the effect produced by traces of nitric acid or ozone by silent discharge at the terminals of high voltage transformers.

In the physical section the investigations will include the effect of time on formation of sludge and the changes in viscosity, specific gravity, flash-point, dielectric strength, and specific resistance accompanying the formation of sludge; the effect of circulating air over the surface of oil on its electrical properties and the formation of sludge; the temperature rise to which oils can be subjected without notable change in their physical properties; whether any standard practice is extant for ascertaining the relative thermal transference in switch and transformer oils, and what standard forms of apparatus should be employed for the purpose.

The chemico-physical points include the effect of specific gravity, viscosity and variation of temperature on the formation of sludge; and whether the amount of carbon produced by an arc in any oil varies with the temperature of the oil, or whether at a constant temperature the amount of carbon varies with the specific gravity and viscosity and other properties of the oils.

### Magnet Steels

In the research on magnet steels the following matters will be investigated: The relation in tungsten steels between percentage content of tungsten and coercive force when carbon content and temperature of quenching are constant; the effect in tungsten steel of manganese and silicon on the coercive force; the magnetic properties of vanadium and molybdenum steels (a) with varying content of V and Mo and the constant carbon, and (b) with constant V and Mo and varying carbon; the relation in high-carbon and in tungsten steels between the ductility or surface hardness and the residual magnetism; the best ratio of length to diameter for bar magnets of a standard tungsten steel; whether the transition temperature at which the steel regains its magnetism corresponds in high or medium-tungsten steels to Ar' or to Ar; the effect on the magnetic qualities of high-tungsten steels of brief preliminary heating to temperatures between 900° and 1,200°, which is known to lower the point of recalescence; a comparison of the values of the self-hardening steels of commerce and standard brands of tungsten steel in respect of remanence or of coercive force; the effect of procuring by prolonged heating in steam (as in the researches of Barus and Stronbal on carbon steel) on the remanence and coercive force of bar magnets of tungsten steel; the values of the coëfficients of self-demagnetization of horseshoe magnets and forms of magnets used in electricity meters; the values of the temperature coëfficients for matured magnets of nearly closed shape made of standard tungsten steel; whether and how the coercive force of matured bar magnets of standard tungsten steel depends on the intensity of the magnetizing field or on the time of magnetization; the magnetic properties of ferro-tungsten, ferro-vanadium and ferro-molybdenum when purified from carbon, silicon, manganese, sulphur and phosphorus; whether in a steel or pearlitic composition heated to 700° and very slowly cooled to 670° in a strong magnetic field any effect on the formation of the pearlitic structure will be produced; distortion as a result of quenching; and loss of magnetism as a result of vibration.

The arrangements for conducting both of these investigations are of a very complete character, and the co-operation of manufacturers and users has been secured to an extent which justifies the anticipation of practical results of more than academic value.

### Producer Gas from Wood Waste

Mr. G. E. Lygo recently read a paper before the Junior Institution of Engineers on the generation of gas from wood waste by means of suction plants of the Whitfield type. He said that the increased cost of coal had induced power users having waste combustible materials at their disposal to consider the installation of wood waste plants in spite of its higher cost as compared with an anthracite plant.

Every kind of woody material could be used, sawdust, cotton seeds, cocoanut shells, fibre, bark, surface peat, up to blocks of wood six inches across. The area of the generator depends on the nature and size of the waste, but as a rule it was about two and a half times the space requisite for coal. For wood in large pieces a deep fuel-bed was necessary to prevent air passing through and causing ignition of gas in the upper part of the generator; while some dense fuels, like sawdust, worked best with a comparatively shallow bed. It was not necessary to use a vaporizer, because the keeping down of the temperature in the combustion zone was not essential.

The plant must provide for the cooling and washing of the gas immediately on leaving the generator, lest the heavy tar and dust should choke the connecting pipe. The Whitfield anti-fluctuator was an ingenious arrangement which ensured a steady flow of gas, and the variation of pressure in the suction stroke seldom exceeded one inch of water, but in a plant without the anti-fluctuator a variation of six inches was often met with.

The calorific value of air-dried wood was about 6,000 B.Th.U. per lb. The consumption per b.h.p. was dependent on the content of moisture, which varied from 10 to 20 per cent in air-dried wood, to 30 to 50 per cent in freshly cut timber. Material containing excessive moisture must be dried until there was not more than 60 per cent, because with a higher moisture content the generator fire would not burn evenly.

The value of the gas produced was higher than that from anthracite, and was from 150 to 170 B.Th.U. per cubic foot as compared with 120 to 140 B.Th.U. for the coal gas.

Comparative costs of working were difficult to arrive at, much depending on whether the fuel could be used for other purposes, although generally it was almost valueless, but putting it at 10s. a ton it would equal anthracite at 25s a tone, and it then became a mere question of convenience. Where the wood waste was used to raise steam with a specially designed boiler the consumption per b.h.p. hour was from 6 lb to 10 lb., but with the producer the consumption was only 2½ to 3 lb. per b.h.p. hour. Experiments with an 84 b.h.p. engine driving a dynamo running at 105 volts gave 540 B.O.T. units for a consumption of 2,072 lb. of fuel, which equalled 3.83 lb. of fuel per kilowatt, with a Whitfield producer, for a ten hours' run.

In a certain factory the same amount of work was now being done with a producer plant, using wood waste alone, as had previously been done by a steam plant which consumed more than 500 tons of coal per annum in addition to the wood waste. His experience went to show that wood-working machinery in a factory made enough waste to produce all the power necessary to drive it when the waste was utilized in a producer, but with a steam plant such a result would rarely if ever be obtained.

### The Alby United Carbide Factories

The report of this company for the year ended on the 30th of June last goes a long way toward justifying the optimistic views of the company's prospects expressed by the chairman at the last annual meeting. The profit on the year's working amounted to £80,448, which affords a dividend of 12½ per cent on the ordinary shares.

For the year 1911-12 the profit was £72,792, and the dividend was 6 per cent, and for 1910-11 the profit amounted to £36,473 and provided a dividend of 5½ per cent. Preference shareholders had the option of converting into ordinary up to July 1, 1913, and they have availed themselves of it to such an extent that the capital account now shows £108,392 of fully-paid preference shares and £441,608 of fully-paid ordinaries.

The company holds 500,000 £1 shares in the recently formed Nitrogen Products and Carbide Company, Ltd., the total capital of which is £2,000,000, and which has absorbed the Nitrogen Fertilizers, Ltd., and the Nitrate Products, Ltd.; and has the controlling interest in the North-Western Cyanamide Company, Ltd., of London, in which it is directly or indirectly interested to the extent of 94,000 shares. Of the 500,000 shares in Nitrogen Products, Ltd., 259,620 were acquired by purchase, and the last balance sheet shows an uncalled liability of £244,620 in respect of these.

### Engineering Imports and Exports

The returns issued by the Board of Trade for the ten months ended on the 30th November show increases in both imports and exports of all the chief classes of engineering materials and products, although the figures for November exhibit a general decline in exports as compared with the corresponding periods of last year. For the ten months the imports of iron and steel, including manufactures, amounted to £12,558,389, and the exports to £45,634,880, the respective increases being £2,068,367 and £6,110,923. Imports of other metals, including manufactures, totaled £27,154,415, an increase of £1,595,432; and exports reached £11,128,323, an increase of £1,113,727. In machinery the imports are valued at £6,101,150, an increase of £455,327, and the exports are put at £30,760,860, an improvement of £3,258,605. New ships were imported to the value of £29,101, an increase of £2,449; whilst exports worth £10,142,785 show a rise of £4,468,843.

For the month of November alone imports of iron and steel increased £108,674, but exports decreased £302,098; imports of other metals fell £367,515, and exports also fell by £174,678; electrical goods showed a rise of £7,035 in imports, but a decline of £189,816 in exports; imports of machinery increased £6,545, and exports decreased £174,574; imports of new ships rose £726, whilst exports decreased by £237,924.

### Market Prices

*November*, 1913

| | £ s. d. |
|---|---|
| Aluminium Ingots, ton | 96. 0. 0 |
| Alum, lump, loose, ton | 5.10. 0 |
| Antimony, Star Regulus, ton | 28.10. 0 |
| Borax, Brit. refined crystal, cwt | 18. 0 |
| Copper sulphate, ton | 24. 0. 0 |
| Caustic soda (70/72%, white), ton | 10. 5. 0 |
| Copper ore, 10 to 25%, unit | 12/1½ to 12. 7½ |
| Ebonite rod, lb. | 4. 6 |
| Hydrochloric acid, cwt | 5. 0 |
| India rubber, Para, fine | 3. 1 |
| Mica, in orig. cases, medium | 3/6 to 6. 0 |
| Petroleum, Russian spot, gal | 9¼ |
| Quicksilver (Spanish), bottle | 7.10. 0 |
| Sal ammoniac, lump, firsts delivered U.K., cwt | 2. 2. 0 |
| Sulphate of ammonia, ton | 13. 0. 0 |
| Sulphur, recovered, ton | 5.10. 0 |
| Shellac, cwt | 4.12. 0 |
| Platinum, oz., nominal | 9. 5. 0 |
| Tin ore, 70%, ton | £112 to £115 |
| Zinc, Vielle Montagne, f.o.b. Antwerp | 25. 0. 0 |

*Tin* opened at £182 and was £183 on the 4th and 5th, thence fell to £179 (11th), and remained between that price and £181.10.0 during the month, being £179 on the 24th, and closing £178.7.6.

*Copper* opened £72.10.0 and declined steeply to £71.10.0, where it remained till the 5th, then again fell, reaching £67 by the 10th; rose to £68.10.0 on the 11th, and held fairly well till the 20th, when it again fell off, touching £65.5.0 on the 24th, which price brought buyers in raising it temporarily to £69 and closing at £66.18.0.

*Hematite* opened at 64/- and dropped to 62/6, then rose sharply to 67/- (4th) and fell away again to 63/- (5th to 10th). It continued to fall slowly, being 61/- on the 24th, and closes same price.

*Cleveland* opened at 51/- and fell away to 49/- in the neighborhood of which price it remained, dropping to 48/7½ on the 21st, and closing at 49/4½.

*Scotch Pig* opened at 57/- and remained steady at just under for four days, then dropping to 56/- (10th) and kept falling till it touched 54/9 on the 18th; recovered to 55/3 on the 19th, but had again relapsed to 54/9 by the 24th and closes at 55/4½.

*Lead* opened £20.5.0 and declined to £19,17.6 (14th) and £19.10 (17th to 20th), and £19.5.0 (21st). It closes at £18.10.0.

*Differences*

*Lower*

| | £ s. d. |
|---|---|
| Copper ore unit | 7½ |
| Sulphate of ammonia | 5. 0 |
| Shellac | 2. 0 |
| Tin, ton | 3.12. 6 |
| Copper | 3.12. 0 |
| Haematite | 3. 0 |
| Cleveland | 1. 4½ |
| Scotch pig | 1. 4½ |
| Lead | 15. 0 |

*Higher*

| | £ s. d. |
|---|---|
| Quicksilver, bottle | 5. 0 |

---

**The Arizona Copper Co.** produced only 1400 tons of copper during the month of November, 1913. Considerable progress has been made in getting the new furnaces into operation.

**A new metallic alloy** of iron, manganese, aluminium and nickel has recently been patented by Walter Rubel, of Berlin, Germany. The metals are melted together in proportions corresponding to the multiples of their atomic weights expressed in the formula $4(FeNi) + 8Al$ Mn. The alloy is said to be useful as an addition to copper and aluminium to form a bronze.

# Utilization of Wood Waste.

## IV—BATH PROCESSES.

BY JOHN E. TEEPLE, PH.D.

Among the various methods of utilizing waste wood or obtaining valuable byproducts from wood, we have mentioned "Bath Processes." It might be difficult to differentiate encyclopediacally between a bath process and a solvent process, or to determine the particular point where a bath ceases to be a bath and becomes a solvent. In practice, however, the two systems have been entirely distinct, have developed independently and worked on entirely different lines. Broadly speaking, the bath has always been non-volatile, and the solvent volatile. The bath has been employed on cord wood and the solvent on disintegrated wood.

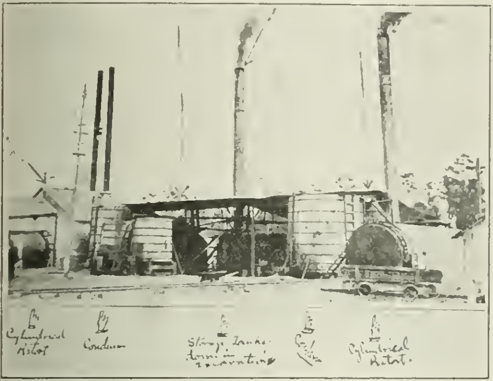


FIG. 1.—GENERAL VIEW OF BATH PROCESS PLANT

The first developments of the bath process were in North Carolina about ten years ago. Two plants of very considerable size were built and later remodeled, but neither of them has operated for several years. The investment here considerably exceeded one hundred thousand dollars. Operations were presumably conducted under the Weed (1905) and the Mackenzie patents.

The next development was in South Carolina where an experimental plant was built to operate under the Davis (1904 and 1906) patents, but by 1907 it had ceased to develop. The next step was the construction of a plant in Georgia operating under the Pope patents. This plant at the present moment is in the hands of a receiver, with outsanding stocks and bonds said to amount to many hundred thousand dollars.

The final progress of the idea was to Florida, where the largest of all the bath process plants was built and started operation in 1911. This last plant also ceased operations during this present year, so that now none of the five attempts is a going concern. On the other hand, conditions and prices that have existed in naval stores this year are unusual, and it may well be that some one or more of these plants under more favorable circumstances might resume operations.

The fundamental idea in all these plants was the use of a liquid bath in actual contact with the wood to remove valuable constituents of the wood. The first bath used was melted rosin. Rosin of the common grades melts around 120 deg. C., and when in a liquid state can be handled readily by pumps through pipes. Details of the process differed of course in the several plants and in the same plant at different times. In one method the wood in four-foot lengths was loaded into cars made of latticed iron and each holding nearly a cord. Ten of these cars were then run into a cylindrical retort and the door closed. In some cases the sides of the retort interiorly were squared up with cement so that the rectangular cars used would occupy nearly all the available space inside the retort. In one case the retorts were concrete instead of steel.

The rosin bath kept liquid in large vats or storage tanks was then pumped through a system of coils used as a heater, and thence into the bottom of the retort at a temperature of, say, 190 deg. C. As pumping continued the bath came into actual contact with the wood, and heated it to a point where the mixed turpentine water and oils in the wood vaporized and left the wood. The bath overflowed into a vaporizing chamber where with the injection of steam, if necessary, the volatile parts were removed and then condensed. Thence the bath returned to the pumps and heaters to continue its circuit until the wood was sufficiently extracted, usually about eight hours. At the end of the extraction the bath was removed from the retort, leaving the wood freed from most of its volatile constituents, still in cordwood shape, still containing its rosin and suitable for fuel or for destructive distillation.

It was assumed in the early stages that the rosin bath would increase by extracting rosin from the wood, so that rosin could be marketed from time to time. Experience, however, usually showed the contrary, and it was more often necessary to replenish the bath with purchased rosin. It will be seen that the operation was continuous during any single distillation, and considerable quantities of rosin were in circulation in the retort, pipes, pump and heater.

A moment's consideration will suggest at once that in any accident causing stoppage of the circulation and cooling of the bath the rosin would "freeze," and there would be heavy bills to pay and no pitch hot. Such an accident occurred more than once in spite of precautions and duplication of machinery. A further disadvantage was the heavy wear on the heating pipes causing leaks. If these leaks occurred inside where they were hidden from view the rosin bath could leak away and serve as fuel for the heater for long periods before it was detected. If the leak occurred in the open there was serious danger to the plant from fire.

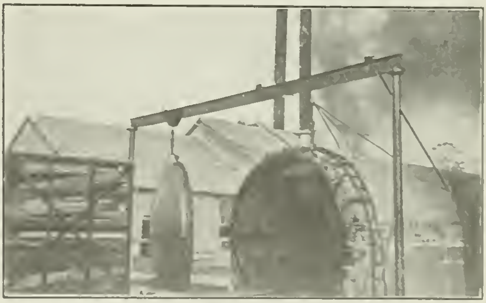


FIG. 2.—CYLINDRICAL RETORT AND CAR OF WOOD IN BATH PROCESS PLANT

As to yields, the claims as usual were liable to be high. The tendency seems to be the same as it is with an applicant for a patent; claim everything in sight, because you certainly will not get credit for anything you don't claim. The ordinary statement given is that 1000 pounds of wood gave 7½ gallons of oil, half of this being turpentine and the remainder oxidized and hydrated derivatives grouped as pine oils, and rosin oils and other decomposition products of the rosin bath caused by the high temperature.

It seems worth while to insist again though, that this whole question of yields is a purely relative one, depending on the wood. You can't get 10 gallons of turpentine out of 8-gallon wood, and one dosen't deserve any particular credit for getting 12 gallons out of 18-gallon wood. The fact that you squeezed two pounds of water out of a sponge while I only squeezed one pound out of another sponge doesn't entitle you to crow over the superority of your squeezing process till we know a little more about the relative capacity and humidity of the two sponges.

I have seen a plant working by the steam process get an average of 7 to 9 gallons of turpentine from its wood day after day, and I have seen the same plant without other change than a little intelligence and forcefulness behind the men in the woods, produce 14 gallons of turpentine per cord day after day, with no material increase in the cost of the wood. Until we are ready to state yields in terms of percentage recovery of all the turpentine, oils and rosin in the wood we can draw very few conclusions from figures excepting as post mortem exhibits to show why the plant died.

In any case the bath processes made reasonable recoveries of turpentine and oils and had over half of their wood left after furnishing fuel to their rosin baths. The last two plants constructed erected destructive distillation plants of the car and oven type to char this wood and obtain tar, charcoal, various oils and some low-grade turpentine. This was a logical step, but apparently more was required to save them from financial difficulty. At any rate none are now in operation. To obviate the difficulties of using a rosin bath many mixed baths were tried, using tar, tar oils, creosote oils, pine oils, pitch, etc., in various proportions with considerable success. It seems reasonable to suppose that under favorable conditions and good management some of these plants may still be a factor in developing the industry.

50 *East Forty-first Street, New York City.*

## International Electrical Congress

### San Francisco, 1915

The International *Electrical* Congress is to be held at San Francisco, September 13 to 18, 1915, under the auspices of the American Institute of Electrical Engineers by authority of the International Electrotechnical Commission, and during the Panama-Pacific International Exposition. Dr. C. P. Steinmetz has accepted the Honorary Presidency of the Congress. The deliberations of the Congress will be divided among twelve sections which will deal exclusively with electricity and electrical practice. There will probably be about 250 papers.

Attention is drawn to the distinction between this Electrical Congress and the International *Engineering* Congress which will be held at San Francisco during the week immediately following the electrical congress. The engineering congress is supported by the Societies of Civil, Mechanical and Marine Engineers and by the Institutes of Mining and Electrical Engineers, as well as by prominent Pacific Coast engineers who are actively engaged in organizing it. This Congress will deal with engineering in a general sense, electrical engineering subjects being limited to one of the eleven sections which will include about twelve papers, treating more particularly applications of electricity in engineering work.

The American Electrochemical Society will hold a meeting in connection with the Electrochemical Section of the International Electrical Congress.

## Notes on Open Up Ozonator Designs

BY A. VOSMAER, PH.D.

For the sake of convenience in handling the subject, ozonators may be classified under two essentially different headings, viz.: those which are based upon the principle of using some solid dielectric between the dischargers, and those which do not make use of any solid dielectric for this purpose. The first named have been the first in the field; they were for a short time threatened to be superseded by the second named class; the result, however, has been that they stand now in the front, stronger than ever.

Although the no-dielectric class has been forced to give way to the other, still it is of interest to discuss the former because it not only gives a better insight into the matter of ozonators in general, but will also cause a better appreciation of the dielectric system, if one knows why the latter has won the victory.

Bearing in mind that the object of discussing the non-dielectric system is to bring forth the advantage and value of the other class, it is logical first to deal with the former.

### 1. Ozonators Without Solid Dielectric Between Electrodes

From the year 1857, when Werner von Siemens made the first commercial ozonator, up to 1894 when Schneller took out his patent, the general thought prevailed that the use of a solid dielectric was essential to having the brush discharge with the exclusion of spark and arc.

Schneller was the first to prove that this is not the case, and it is interesting to note how a totally wrong reasoning led him to an arrangement that actually did work, though poorly.

Schneller assumed that the rôle of the dielectric was that of a high resistance in the path of the electricity and argued that as this was so we can as well place it somewhere else in the circuit and use some other material for it.

So he arranged his circuit in such a way that one of the terminals of the high—very high—tension transformer was connected to what he called a specific resistance, and from there to the sharp pointed discharger, discharging against a flat surface which was connected to the other terminal of the transformer and for the sake of convenience also to the earth.

We shall come back to this arrangement later on. Whatever we may think of the idea, it certainly proved that a solid dielectric between the dischargers was not an essential point in the art.

The second way of doing away with a dielectric (we shall henceforth thus abbreviate the expression of a solid dielectric between the electrodes) was to have recourse to high-frequency currents. This was Tesla's method.

The third method was Otto's, based upon the principle that an arc when drawn out will thereby be extinguished. Otto used revolving electrodes, that is to say, one revolving electrode inside of one fixed electrode.

When I saw Schneller's system at work and on the one hand was thereby convinced that the dielectric is not a *conditio sine qua non* for the maintenance of brush discharges, but also convinced, on the other hand, that Schneller's method was based upon a wrong assumption, I began to investigate the subject. After a good many years of experimental research and careful investigation I finally found that the whole secret of the matter lies in a true harmony between the different items that enter into consideration—voltage, polar distance, shape and size of each of the dischargers proper, kind of current supplied, etc.

If there be true harmony between all of these, then and only then is it possible to have brush discharges and nothing but these going on and on any scale required.

So I got my first patent in the year 1897, but in actual practice it soon turned out that perfect harmony once established does not always stay on. For instance, some alteration in the speed of the dynamo will give rise to a change in voltage which may be large enough to endanger the state of equilibrium. That is the reason why I was very fortunate in finding an automatic device that absolutely controlled the system. I will discuss this later.

These four are the systems which work without a dielectric and are thus essentially differentiated from the dielectric system and also from each other. There are some interesting scientitfic details involved in these different systems which may be discussed, not on account of their commercial interest, since none of these systems has any commercial interest at all, but for the reason that they are of value for understanding the history and the development of the dielectric system.

### (a) The Schneller System

Fig. 1 gives a diagrammatic sketch of Schneller's idea. Tr is the transformer, E the earth connection, O the ozonator and G the "specific resistance," as he calls them. This was a glass tube filled with about 80 per cent. glycerine the apparent ohmic resistance of which amounted to about 20 million ohms. In his large ozonizer (2 K W) there were 75 of these tubes connected in parallel to as many double discharging combs. The secondary tension was about 50,000 to 60,000 volts. All these figures refer to the original Tindal plant in Holland.

The actual working of that plant aroused in 1895 quite a stir. A great many scientists came to see this wonder, and full credit must be given to Tindal, who owned the Schneller patents, for having been the first to demonstrate on a fairly large scale the possibility of the sterilization of drinking water by ozone.

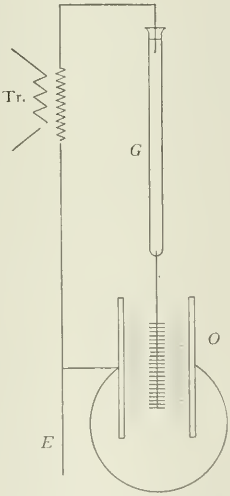


FIG. 1.—SCHNELLER SYSTEM

The first electrical question that at once comes up is this: Why did he use 75 tubes of 20 million ohms each in parallel instead of one of equivalent value? And the next question is this: Can that liquid resistance be supplanted by a solid one?

The inventor himself was never able to answer these questions and it has taken me considerable time to find out that said specific resistances did not work as such and could not be replaced by an ordinary metallic resistance, and that tubes filled with glycerine do not act through their considerable ohmic resistance but actually act as a pseudo-capacity of large value. If one inserts a condenser of large capacity in the system in series, then one obtains exactly the same result. The voltaic arc will not be checked *unless* the voltage be very carefully watched, so that it would never rise above a certain limit.

I remember when working with Tindal that to my great surprise they were very careful about the voltage. A man was watching it continuously. My surprise was due to the fact that the patentee claimed to be sure of brush discharges and to keep out other kinds of discharges.

*A posteriori* it is all very clear, but at that time it was called a "wonder." The mistake of the Tindal people was that they did not work on a scientific basis. They did not know actually what they were doing, although the performance, being pioneer work, should be given full credit. It is so much easier to criticize afterwards than to invent before the realization of an idea.

In 1898 the same Tindal and Schneller patented an ozonator based upon the principle of the use of a dielectric, viz.: a layer of enamel, and had the shrewdness not to call this a dielectric but a means of obtaining a smooth surface.

It is a pity that the financial generosity of Tindal has not resulted in a better system. He was the man to whom we are all indebted for the knowledge of the wonderful effect of ozone on water. He gave the impetus for working out this scientific problem on a large commercial scale. Tindal died several years ago.

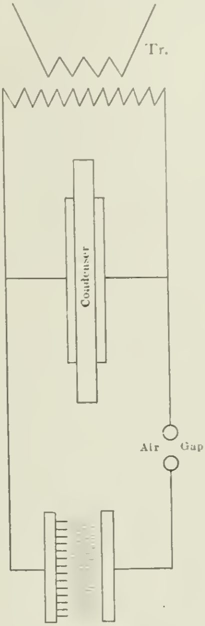
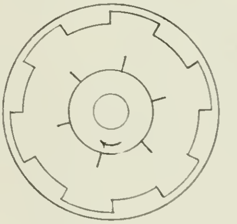


FIG. 2.—TESLA SYSTEM

### (b) The Tesla System

This system is too well known to need much comment. The special circuit comprising a condenser in shunt and a spark gap in series is familiar to all. The most strikingly beautiful brush discharges can thereby be obtained now without the least fear of arcing and have been enjoyed as a grand sight by many, but for the purpose of ozone making there is one objection to it. The yield of ozone per kw-hour is far too low in comparison to other systems, and this fact has prevented any actual use of it on large scale.

The diagrammatical sketch, Fig. 2, shows the principle.



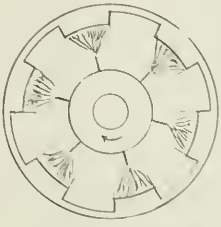


FIG. 3.—OTTO SYSTEM

### (c) The Otto System

If Otto, when he applied for his revolving-electrode patent, had known that it is better to prevent than to cure, and that prevention of arcs is quite possible when there is harmony between the revolving speed and the periodicity of the current, his system might have been an improvement. But as it is, not much benefit is to be derived from the arrangement.

Fig. 3 shows the principle in sketch. It is evident that there can only be here a question of cutting off arcs after they have been established, instead of making their appearance impossible. Had he claimed to turn the revolving electrode in synchronism with the alternating current, then the arc could have been avoided.

### (d) The Vosmaer System

If, in order to obtain brush discharges and nothing but these, it is not necessary to have recourse to high-frequency current, or to the intercalation of a very high resistance, nor to have one or both electrodes in motion, what, then, is required to have things go as desired? This is the vital question. It is very easy to answer, however, because actual experiment on a large scale—up to 10 kw—has shown me that nothing else is required than to understand the subject thoroughly and on this basis to establish true harmony between the different electrical apparatuses.

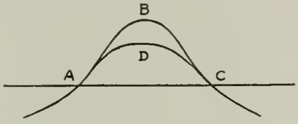


FIG. 4.—VOLTAGE WAVE CURVES

Remember that the spark is a disruptive oscillatory discharge, requiring a high density of electric charge at the place of discharge—hence the use of large spheres for this purpose.

Remember, too, that the voltaic arc has conditions of its own, that it represents the low-tension, high current-density discharge, started by actual transport of solid matter and continued by the conduction of gaseous matter at very high temperature, that the arc is started at small polar distance and can then be drawn out.

All these conditions are not fulfilled when one has a needle-pointed electrode, spaced at a distance of say half an inch from the other pole; when the potential difference is gradually increased there comes a moment when a brush is formed. If the voltage is kept at that value or a little higher it is possible to maintain the brush.[1] In my 2-kw. ozonator I could arrange it so that all this energy was taken up by brushes, no less than 240,000 needles being used in the apparatus.

The flow of electricity is such an even one, so smooth and regular, that no interruption need be feared, unless —and that is the point—there is a reason for it in the form of rise in voltage or particles of dust or metal playing the rôle of a solid conveyor from pole to pole.

The brush discharge from an alternating current supply is an intermittent one, in the first place because the points do not discharge unless they are positive; in the second place because the voltage is a wave and a certain minimum voltage is essential to discharge.

If the actual voltage wave be considered to be sinusoidal, the actual discharge voltage wave will be something like Fig. 4 shows, because the regular flow-off of electricity will prevent the tension to reach its maximum value.

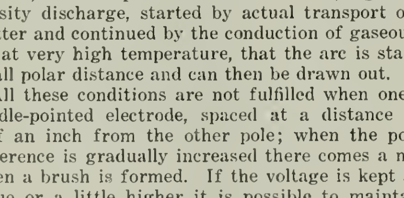


FIG. 5.—VOSMAER OZONATOR CONNECTIONS

Thus theoretically there is no difficulty in maintaining a regular brush discharge from properly shaped electrodes at proper distance, but in actual practical work it is hardly possible to realize the condition of absolute constant voltage and absolute dust-free air, and some means had to be provided for guarding against accidental circumstances.

That automatic safety arrangement was as follows:

In the circuit from the transformer secondary ends to the ozonator electrodes there is a condenser in shunt, and a reactance coil in series (see Fig. 5). The object of this arrangement is that, through the combined effect of capacity and self-induction, one in shunt and the other in series, the original transformer tension is raised to a considerable extent, in fact multiplied by any number up to 15. Perhaps that is not the limit, though it was the limit in our experiments.

In actual work no such intense raise is wanted, my regular work having been done with a raise of not more than from 7700 to 10,000 volts. By this I want to say that the primary tension was 110 volts and the ratio of transformation being 70, that would give 7700 volts at the secondary terminals, but the special way of connecting up (patented by me and my partner, Dr. Lebret, in the year 1902) causes the tension to be 10,000 volts.

This raise of tension, however, also depends, as regards its magnitude, on the value of the resistance at O. As soon as this drops, say on account of a spark caused by a particle of metal, then said raise in tension drops also, and by so doing ends the spark; in this way the spark is killed by its birth or even before that, because even the *tendency* to start sparking is *checked* by the special circuit.

Arcing is an absolute impossibility, as was repeatedly demonstrated when raising the primary voltage on purpose, say to some 20 per cent. The way of connecting up is altogether against the nature of voltaic arcs.[1]

It is useless to tell of all the technical difficulties that had to be surmounted before a 20-kw unit could be made. It worked beautifully. Occasional sparks were promptly extinguished. But my system for which I had been working so hard had to suffer the same fate as all the others. It had to give way to a better one, better taken in the sense of efficiency as regards output of ozone per kw-hour.

### II. Ozonators With a Solid Dielectric Between Electrodes

### (a) The Dielectric

The dielectric in an ozonator is subjected not only to the electric stress put on it, which, by the way, is a very severe one, but also to the heating effect of the discharge. We remind the reader that no more than 10 per cent. of the electrical energy is converted into ozone,[2] the rest is wasted as heat. Then there is the destructive effect of the ozone and the mechanical effect of the continual bombardment of charged molecules of gas.

There are not many materials that will stand all this. In fact there is but one at the present moment, viz., glass.

Nearly all the insulators made of or containing organic matter fail on account of the rapid destruction of it by the ozone generated, this being more especially the case with all those which contain rubber.

There are several lacquers that are not oxidized by ozone, for instance, shellac, and it might be that use could be made of this material. However, it is worth knowing that all laminated materials, such as micanite, shellaced paper, etc., cannot be used on account of their liability to peel off when subjected to the discharge and heat.

Celluloid cannot be used on account of the danger of taking fire. Vulcan fiber and fibrous material like it is no good at all because the discharge will "eat" its way through.

---

[1] See the Brush Discharge, by A. Vosmaer, Met. & Chem. Engineering, Nov., 1913.

[2] See Ozone, by A. Vosmaer, Met. & Chem. Engineering, Dec., 1913.

Amongst the minerals there are but few that can be had in a convenient shape. But slate and mica have been in use. The first, however, is by far too irregular in insulating properties; the second is an excellent insulator, but its peculiar property of being a highly laminated structure excludes its use for the purpose in mind.

That leaves one more group, viz., glass, enamel, porcelain and quartz. Enamel is a kind of leadglass containing a considerable amount of metallic oxides. It is a very poor insulator, very sensitive to rise of temperature, very seldom a homogeneous mixture, and no good at all for the purpose. Strange to say, porcelain does not give satisfaction at all; when used in ozonators for a dielectric it very soon gives way; small perforations are set up within shortly, and that, of course, results in the voltaic arc which means ruin to the ozonator.

I believe this strange behavior of a material so highly appreciated in other branches of electrical engineering is due to the fact that after all porcelain is not a material of homogeneous composition. Quartz and its kindred substitutes, fails for the same reason. Its fusion has not been a complete one. The molecular cohesion is rather poor. It is very brittle. But it may be and we might even say it is possible that before long, properly fused quartz can be obtained in large masses and in convenient size and form.

Thus really nothing is left but glass. Now, glass is a collective name for a large class of material. There is such a variety in quality, properties and make that some classification has to be made.

The so-called lead glass does not possess the properties sought for. Of the sodium and potassium-lime glasses the latter is to be preferred; that is the kind known as hard glass, manufactured as a specialty in Bohemia. It is a flint glass of good composition.

Glass has the advantage over several other materials that it can be had in almost any conceivable shape, of any size and any weight, up to a certain limit, of course—which limit is never reached in ozonators, however.

A great many failures of ozonators are due to the unsuitable quality of the glass used as dielectric. Many laymen who also are ozonator inventors—and there are many of these—think glass is glass and they take the cheapest kind they can get.

But the manufacture of glass has become quite a scientific art and it is very probable that when the demand comes, glass manufacturers will be able to supply a kind of glass that just suits the purpose to a nicety.

As the situation is now, there is always some danger, because glass is a treacherous material. It may look well outside, but the inside may be largely overstrained, internal stresses being difficult to overcome. For the present the best policy seems to be to try all samples and keep the good ones.

The dielectric strength of glass varies between so wide limits and depends on so many circumstances that definite figures cannot be given. For one millimeter of thickness it may be between 10,000 and 70,000 volts. It largely depends on the shape and size of the electrodes used, on the kind of current, viz., direct or alternating current, on periodicity and very largely on the temperature, so that the variations are too large to give an average figure.

The effect of temperature on the dielectric strength is a very marked one. Glass is a regular electrolytic conductor at high temperatures, and that is one of the traps for ozonators. If through excessive strain the dielectric should become too hot it gives way through simple conduction, thereby establishing the arc discharge.

The conductivity of insulators is a very fascinating subject to discuss, but would lead us too far away from our subject.

Let it be sufficient for the present to state that the right kind of glass suits the purpose of its use in ozonators as a dielectric very well if all conditions are judiciously chosen and thought over and checked by experience.

### (b) Principle of Arrangement

In Fig. 6 are sketched more or less different ways of placing the dielectric showing in (*a*) one glass dielectric and two air spaces, in (*b*) we see the omission of one of the two air spaces, in (*c*) we have one air space and two glass dielectrics, while (*d*) is merely a change in construction. Now these different ways can be combined to different shapes of electrodes, and that gives all the possibilities—not very many, indeed.

Details of construction may, however, bring about a great change in efficiency. For example, if ozone of great concentration be wanted, then there should be a great amount of electrical energy discharging in a small space. This, however, also means a great amount of heat, and it is absolutely necessary to carry away this heat through effective cooling of electrodes and dielectric, and this is a condition not so very easily fulfilled.

It is immaterial, as regards the principle, whether the glass be flat or curved. This means that it makes no difference whether the ozonator is built up of plates or of tubes. Some people have their reasons for preferring the plain plate, others again prefer the tube. Some are using all sorts of fancy shapes of electrodes, others believe in simplicity.

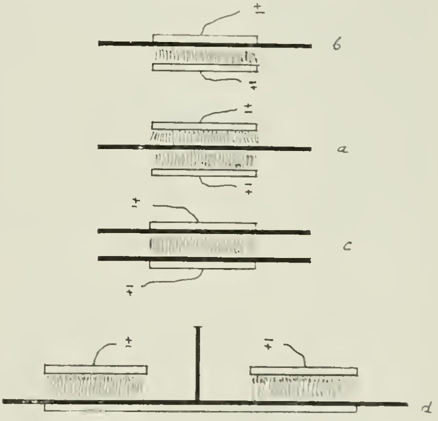


FIG. 6.—DIFFERENT ARRANGEMENTS OF DIELECTRIC

There is much less difficulty in constructing an ozonator for low concentration than there is for high concentration. For ventilating purposes, where a very low concentration is wanted, there is no need of artificial cooling, since the air passing through takes care of that.

Again, in small-size ozonators for individual use, the yield of ozone per kw-hour is of far less importance than the simplicity of the apparatus, so that, after all, though there is not much variety in the principle underlying different ozonators, there is quite enough variety in the several makes.

### (c) Some Ozonators

#### THE SIEMENS OZONATOR

Werner Siemens was the first who constructed ozonators on a commercial basis, and after several improvements the Siemens tube still holds a prominent place. The first trial was made with an apparatus built up of two coaxial glass tubes, either coated respectively inside and outside with tinfoil and partly filled with acidulated water.

Here we have a case of two dielectrics and one air space.

Later on use was made of mica tubes, which, of course, did not give satisfaction. Then the firm developed an apparatus built up of large plate glass dielectrics, but after in actual service it had been proved that the glass tube either makes a better apparatus or gives better results, the later Siemens ozonators are now substantially built glass apparatus, six of them joined in one casing. They consist of one electrode of metal, an air space, one glass cylinder as solid dielectric, then a liquid electrode, which serves the purpose of cooling at the same time, as shown in Fig. 7.

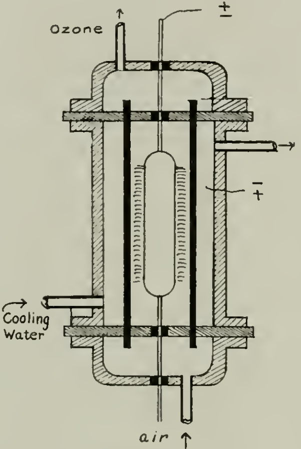


FIG. 7.—SIEMENS OZONATOR

We are all familiar with the general appearance of this type of ozonator, which has been published so many times on account of its being tested on a large scale and found to be efficient and reliable. The large European ozone plants are using this type of ozonator, which proves its fitness to do the work.

We may consider the Siemens tube to be the outcome of the original Berthelot laboratory apparatus.

### THE GIRARD OZONATOR

The original Berthelot tube for laboratory use, modified so as to become an industrial ozonator, is what is the Gerard tube, the most prominent feature of which is the high output in ozone per kw.-hour.

The principle is that of Fig. 8, showing two dielectrics, one air space and two metallic electrodes, one of which is energetically cooled with oil. It seems that this arrangement is the best for producing high concentrations of ozone, although it is difficult to understand why it should be superior to the one-dielectric system.

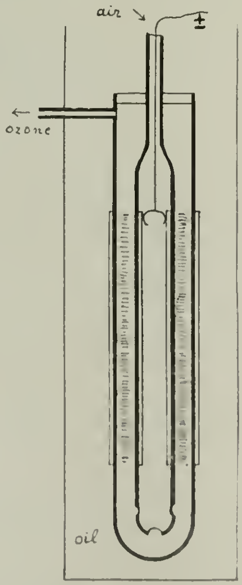


FIG. 8.—GERARD OZONATOR

### THE OTTO OZONATOR

On finding that after all the rotating electrodes did not prevent the arc, Otto finally also took up the dielectric system, and kept his revolving electrodes, although the advantage of this moving part is not very obvious.

### THE VOHR OZONATOR

Realizing the difficulty of obtaining a glass that will suit the purpose, and realizing that such is still more so in the case of tubes or cylinders, the Hudson Ozone Machine Company has arranged an ozonator in the style of a grid. It certainly has the advantage of cheapness as regards the dielectric, which in this case consists of nothing but strips of glass, easy to replace in case of damage and made of choice glass.

In the accompanying sketch, Fig. 9, its simplicity shows itself clearly. The electrodes discharge from both sides. As there is no artificial cooling the current density per surface of electrode has to be kept low so as not to cause a dangerous rise of temperature.

The grids are made in units and can be joined in a suitable casing. The system does not allow of obtaining extremely high concentrations, but as said repeatedly there hardly is a need for those very high concentrations. Personally I have done all the work with a concentration as low as one or a little over one gram per cubic meter, and that is quite enough, except in some very special cases. The secret of the use of low-concentration ozone lies in the knowledge of exactly the best way of application, and that is a matter of experience.

There are several other ozonators on the market yet, and we could lengthen this article by enumerating and describing them from the patents, but that is not the object of this article. On the contrary, I have been endeavoring to condense it as much as consistent with good understanding. Moreover, as it is only in details that different makes differ, it would be of little interest to repeat again what has already been said so often.

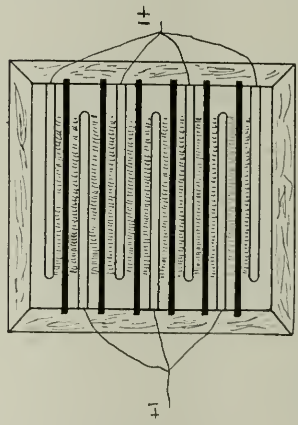


FIG. 9.—VOHR OZONATOR

I wish to conclude this by reminding the reader and prospective user of ozonators that at present they can be had for any concentration up to say 30 grams of ozone per cubic meter and for any quantity.

The Gerard and the Siemens apparatus seem particularly adapted for the manufacture of high-concentration ozone, the Vohr suits the purpose of lower concentration. Just what concentration is wanted for a given purpose cannot be said in a few words. The output per kw-hour is less for a high than it is for a low concentration so that it would be bad policy to first make a highly concentrated ozone and dilute it by mixing with more air. Most of the present applications of ozone can be successfully carried out with a concentration of about one gram per cubic meter of air; some require 3 to 5 grams, some no more than one milligram (see the article in the December number).

The vital point for an ozonator to do its work and to do it satisfactorily is that it shall not be run to its utmost capacity. It is better to stay a long way off that, because the more energy is used per unit of surface the higher the concentration and the higher the yield, *but* at the risk of a breakdown.

A common mistake of most people who start working on ozone is to push the discharge. At its best, this method gives high figures for output but does great damage to the reliability of the apparatus. Experience must tell the operator the safe limit for continuous operation.

No more than 5% as a rule and never more than 10% of the energy is usefully employed in the conversion to ozone, the rest is wasted as heat and should be taken care of accordingly.

By way of comparison it may be said that the original Schneller system gave 4 grams of ozone per kw-hour, his latter system gave 7, the Vosmer system gave 12, the Siemens 30, the Gerard is said to give 50 to 80. These figures must not be looked upon as of much importance. They are liable to change according to circumstances and are not strictly comparable.

It is a mistake to look only for high output per kw-hour. There are many other items of as much or sometimes even of more importance, for instance, reliability, constancy, cost of installation, cost of maintenance, and many others.

From an electrical standpoint ozonators may be looked upon as condensers of enormous capacity, both pseudo and real, and as this is a rather unusual load for an alternator, the phase difference should be corrected by some self-induction so as to get the full power out of the alternator. This point is generally overlooked. We are used to look out for self-induction, but capacity is just as bad. It is less common and hence less thought of. We all know of the Ferranti effect caused by the capacity of long cables but here we have a case of extremely high capacity not met with in the ordinary daily practice.

Ozonators are always run in parallel and it is safe to group a number to be fed by one transformer so as to be free in making repairs or changes without interfering with the rest of the machines.

The fact that glass has to be used for ozonators and that it is liable to break, limits the size of a single apparatus to a convenient size. Hence their great number in large plants such as are now in very successful operation in Europe.

Those who never worked in the field of ozonators usually wonder why it is not practical to place a large number of them close together and have one casing for them. Well, the reason is that apart from the fact that one has to provide for a large cooling surface, there is another objection to doing so, that is their individual electric fields. These are obnoxious in a terrible way. These individual electric fields are rather hard to calculate and not so easy to shield off as one might expect from ordinary work.

It is all a question of experience to be able to arrange matters in a satisfactory way, here as in any other branch of applied science, but here especially, because rather unusual factors are here encountered. But the fact that in Europe many very large plants do operate satisfactorily indicates that experts have overcome all the difficulties, and it is to be expected that within the near future ozonators will be as common apparatus as electric furnaces.

*341 St. Johns Place,*
*Brooklyn, N. Y.*

---

**The United States mineral production** for 1912 as finally announced by the Geological Survey, was the greatest in the history of the country, exceeding even that of 1907, which has been considered the boom year. The total value of production was two and a quarter billion dollars.

**Montana leads other states** in the production of precious stones, this supremacy being due to the mining of sapphire. The value of these gems produced in 1912 was $200,585. The total value of metal production of Montana in 1912 was $70,000,000.

---

# History of Electric Furnaces

BY WOOLSEY MCA. JOHNSON AND GEORGE N. SIEGER

The electric furnace can be described as a short circuit under control. It can also be defined as a metallurgical apparatus for the utilization of the thermal effects of the electric current for an industrial purpose. Electrical energy is turned into "commercial energy," or something is given "form-value" by the electric furnace. The thing that is the driving force of the industrial operation is the electric current and the thing by which the energy is usefully applied is the electric furnace.

Now so long as power was derived from some primary electric battery no practical effect was attained for the reason that it was too difficult to get power enough to do much work in the electric furnace, even though the cost was not at all considered. Later the dynamo was practicalized by Edison, Siemens and others. When this was done some adequate source of power was at hand and the experimenter having a generator upon which he could rely, could turn his attention to the electric furnace.

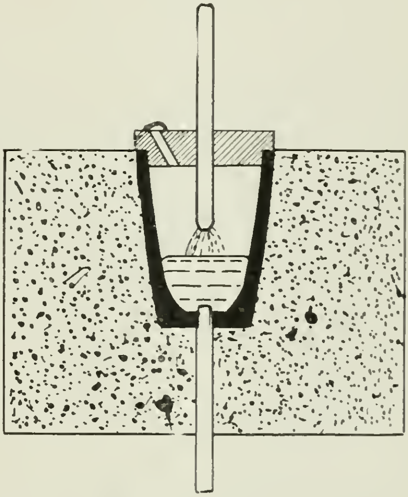


FIG. 1.—VERTICAL ARC TYPE OF ELECTRIC FURNACE

Accordingly, prior to 1876 we find but little accomplished in the electric furnace save of purely scientific interest. Sir Humphrey Davy—in 1800—was alive to the possibilities of electrically generated heat and built a small "arc" furnace. Henry, at Princeton College, New Jersey, had an electric furnace that was more than a scientific toy. Pepys in 1815 made a few scientific experiments.

Despretz, in 1849, made the original furnace of the "resistance" type. But this was the "scientific" age of electric furnaces, when it was used by the investigator simply as an aid to scientific experimental work.

In 1881 Edison first exhibited the dynamo or electric generator and electric motor. This machinery had the virtue that it worked and was reliable and durable. Such parts and accessories as fuses, switches, porcelain cleats, insulated wire, etc., were developed by the American inventor as essential details of the dynamo in a form identical with the present form though crude.

With the practicalization of the dynamo the inventor of the electric furnace had a source of power that could be relied upon. And thus the practical stage of the electric furnace started. Sir W. Siemens, in 1878, exhibited to the Royal Society at London an electric furnace of the vertical "arc" type in which he melted several pounds of steel and boiled off several pounds of copper. See Fig. 1. This furnace is the prototype of the Heroult steel refining furnace and indeed of any furnace that uses a vertical electrode.

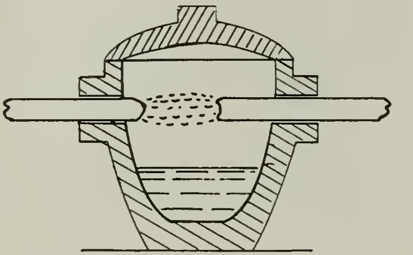


FIG. 2.—HORIZONTAL ARC FURNACE

Siemens also exhibited a horizontal "arc" furnace in which the heat is reflected down to the charge. This is the prototype of the reveberatory arc furnace such as is used by Stassano for refining or melting steel, by the late G. P. de Laval for smelting zinc ores and by Weeks for distilling crude zinc. See Fig. 2.

From the Siemens vertical type of furnace followed the Heroult-Hall electrolytic furnace for the production of aluminium. This was followed by the Wilson Carbide furnace. See Fig. 6. From these two came the slag resistance furnace or the buried arc type in such common use in the manufacture of the ferro-alloys. Siemens therefore can be regarded as the father of the "arc" type of furnace.

In 1883 E. H. and A. H. Cowles took up the question of smelting by electricity the zinc-copper ores of a mine near Santa Fé, New Mexico. Though the Cowles brothers were unsuccessful in this attempt they did develop the "resistance" type of furnace. See Fig. 4. In this a core of conducting carbon as coke in the charge itself carries the current in a horizontal direction. While no direct commercial result, at least no commercial result pronouncedly successful ensued, yet from this furnace was derived more or less indirectly the resistance furnace of Acheson for the making of graphite or carborundum. See Fig. 5.

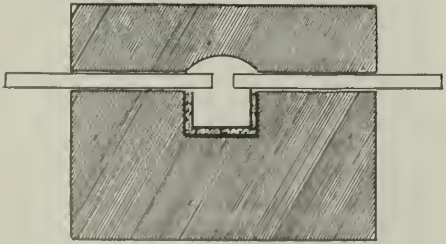


FIG. 3.—MOISSAN FURNACE

Along in 1890 the industrial limits of the electric furnace were clearly seen by certain far-sighted men, and it was recognized that the electric heat could only be used for such purposes as its specific innate advantages gave it a metallurgical monopoly.

This had been evident in the production of aluminium. Here by the combined power of electric heat and electrolytic effect, a metal that sold for $5.00 per pound had been reduced to 50 cents per pound. In calcium carbide, artificial graphite, and in carborundum there was found a useful product which could only be made in the electric furnace.

About the same time, water powers became harnessed and it was fashionable in financial circles to develop hydro-electric installations. This gave a large supply of power for which there was not a great demand except at low rates when sold in large quantities.

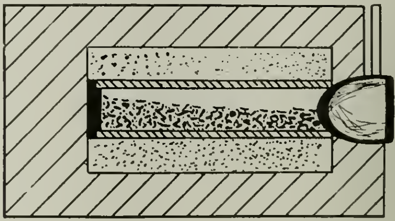


FIG. 4.—COWLES RESISTANCE FURNACE

About 1890 the real "commercial" age of the electric furnace started. The generator was developed to a practical stage, there was an abundance of cheap power and enough research work had been done to give the art the means of applying to industrial purposes the electric energy.

Along in 1890 Henri Moissan, a professor at Sorbonne, Paris, performed his spectacular researches on the electric furnaces. See Fig. 3. With upward of 200 hp at his disposal he concentrated this in less than a cubic foot of laboratory space. As electric furnaces nowadays rarely work at a power density greater than 20 kw per cubic foot, the results attained were remarkable. Almost any oxide was reduced, metals were boiled off in a short time, and the carbides of metals formed.

Unfortunately, such an operation, while it was brilliant from a scientific standpoint, especially the manufacture of diamonds, was not an unmixed blessing to electrometallurgy, for it gave rise to hopes and anticipations from which there was little realization.

When the calcium carbide business began to lag before acetylene found its present large uses, the companies making it turned their energies largely to the manufacture of ferro-alloys. As most of these are difficultly reducible, the electric furnace became the proper metallurgical means to employ. Along in 1905 the production of ferrosilicon high in silicon became an industrial success of importance. Ferro-vanadium, ferro-chrome, ferro-molybdenum and ferro-titanium followed. This expansion was due in part to the increasing demands of the metal business for these alloys which were used as a basis for special steels or as scavengers in the manufacture of steel. This business has in certain cases been markedly successful in producing profits.

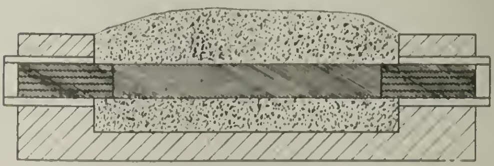


FIG. 5.—ACHESON RESISTANCE FURNACE

About 1905 the production of fine tool steel in the electric furnace came into engineering prominence. Steel when made in the crucible is expensive but its duty is hard, for tool steel must be as nearly perfect as is practically possible to manufacture. The cost of production is large for the crucibles are expensive, the labor charge high, and the thermal efficiency miserably low. In either the Bessemer converter or the open-hearth furnace, it is hard to make steel dense without infinitesimal blow-holes or "sonims." The process of electric refining is more expensive but the quality of the product that can be made compensates for its higher cost. In the electric steel furnace there is a neutral atmosphere and the steel is "dead-killed." The reaction between the sub-oxide of iron and iron carbide is brought to a state of stable chemical equilibrium and the steel is never poured "gassy" while it is not an easy task to always pour steel dead quiet from a Bessemer converter or from an open-hearth furnace.

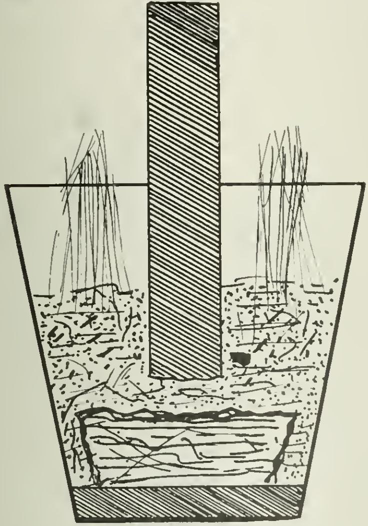


FIG. 6—WILSON CARBIDE FURNACE

It seems an economic mistake for the electric furnace engineer to have tried to refine "tonnage" steel in the electric furnace when the crucible steel business lay open as a much easier point of attack in spite of the conservatism of the crucible steel makers. But the genius of Heroult had developed the combined process of partial refining by fire processes with subsequent electric furnace treatment. With the demand for heavy section rails by the railroads of great hardness and great toughness and with the proven industrial success of electric steel castings such as is done at Schenectady by the General Electric Co., however, the electric steel furnace on which Heroult has spent so much time, money and energy and to which art he has contrbuted so much, has two avenues of commercial expansion. There are few businesses that offer so great a profit with so little risk as does the manufacture of steel castings from cheap preheated scrap in the electric furnace.

The "induction" furnace has been subjected to commercial exploitation. It has had some success abroad but practically none in this country, for it is doubtful if of the 200,000 odd tons of steel made in the electric furnace in the United States one per cent has been made in the electric "induction" furnace.

The manufacture of carborundum came from the chance invention of E. G. Acheson. He noticed a hard substance in some electric furnace experiments. These were harder than glass and would slightly cut the diamond itself. From this came the carborundum furnace in which a mixture of sand and coal dust are turned into a useful abrasive. Mr. Acheson noticed, after his carborundum process had been commercialized, a layer of graphite in what had been the hottest zone of the furnace. This, he reasoned, had been formed by the decomposition of the silicon carbide. Accordingly, he developed the manufacture of artificial graphite by employing iron oxide or other substance to act as a high temperature catalyser to graphitize the carbon.

This process was successfully turned into the manufacture of graphite electrodes which have been in and of great service both in electrolytic and electric furnace work. It is hard to see how many electrolytic processes could be used at all without Acheson graphite anodes. Acheson graphite has the great advantage of standing sudden temperature changes without breaking. Often the increase of service more than pays for double increased cost as compared to carbon electrodes, although in most instances the value ratio to carbon is about 2.5 to 1.

With all these successful developments from 1890 to 1905 (the unsuccessful electric furnaces have perished and are forgotten) we might almost say that we have reached the end of the first "commercial" stage of the electric furnace. The electric furnace proved its usefulness in certain fields of its own. It did not begin to invade the field where the "carbon heated" furnace was clearly established until 1905.

Such developments as the manufacture of calcium nitrate in the electric furnace was along the lines of metallurgical monopolies.

In 1905 the advance of the old and tried processes began. The only two that had been successful before were the manufacture of carbon disulphide by Taylor and of phosphorus by the Oldbury Chemical Co. The electric steel furnace has proved its commercial worth in the manufacture of tool steel. The electric zinc ore smelting furnace and the electric brass furnace are destined to successfully invade the field now held by the zinc retort and the brass crucible.

The electric current is a powerful metallurgical instrument. But a keen sense of its own limitations must be present in the minds of the designer, inventor and promotor. The electric current resembles to the authors' ways of thinking—a hydraulic jack, but a hydraulic jack, while adapted for raising a steel furnace, is not made for raising a packing box.

---

**Paving Brick from Blast-Furnace Slag.**—At Middlesborough, England, several companies are engaged in the manufacture of brick from slag. The latter is taken from the furnaces in a car from which the molten slag is run into moulds carried on a wheel. The brick formed from the congealed slag is subjected to an annealing process before they are ready for use.

**The Iron and Steel Institute** announces the annual award of a research scholarship or scholarships, of such value as may appear expedient to the Council, founded by Mr. Andrew Carnegie, who has presented the Institute with $100,000 for the purpose. The award is to be made without respect to sex or nationality. Candidates must be under thirty-five years of age. The object of the scholarships is to conduct researches in the metallurgy of iron and steel. No restriction is placed on the locality in which research is to be carried on, provided it be properly equipped for the purpose. Appointments are for one, renewable at the discretion of the Council; the results of research are to be communicated to the Institute. Persons interested may secure further information by applying to G. C. Lloyd, secretary, 28 Victoria Street, London.

# Handling the Raw Materials at the Iron Blast Furnace

BY J. E. JOHNSON, JR.

The average output of blast furnaces has increased in little more than a generation from about thirty tons per day to about five hundred tons per day. This great increase has occurred simultaneously with a decrease in the supply of labor relative to the demand, and a great increase in its cost.

These two circumstances have brought about great changes in the methods of handling the raw materials for pig iron manufacture. These materials are so generally ore, coke and limestone, that unless definitely stated, to the contrary, they will be meant when the term raw materials is used. In furnace parlance these are also known under the name of "stock," and the building in which the supply is stored to cover irregularities in daily receipts is known as the "stock house," a term which has survived the existence of any actual house.

The prime condition for successful operation of the furnace is that it must be run continuously. This is a fact that it will be necessary to emphasize many times in subsequent chapters. This term means literally twenty-four hours a day, seven days a week, fifty-two weeks a year, and for several years at a stretch. To enable furnaces to be operated in this way a supply of raw materials must always be on hand, in spite of the interruption to transportation of supplies, and other conditions which make regular daily receipts impossible. The first and obvious one of these conditions is the occurrence of Sunday, when transportation is always partly and generally wholly suspended. This makes it indispensable to have a supply of raw materials large enough as a minimum for two or three days' run, and rising as high as a six months' supply in many cases.

In the old days of small charcoal furnaces these were generally built close alongside of a very steep hill, and had a bridge running from the top of the furnace over to a leveled yard or space on the hill, served by a wagon road with an approach long enough to permit the hill to be surmounted. All raw materials were delivered by team into the stock house built on this level space, and unloaded, at first by shoveling from the wagons, later by wagons with loose bottoms, which could be pulled out, one board at a time. These materials were shoveled by hand into filling barrows, which were then wheeled onto a platform scale set for the correct weight of the given materials. The weight was adjusted by shoveling into or out of the barrows to make the balance correct, and the barrows were then wheeled across the bridge to the top of the furnace and there dumped. Of other equipment besides shovels, barrows and scales there was none. The number of men employed was not very great because the quantity of material handled in a day was small. Fifty years ago it probably did not average much over one hundred tons in twenty-four hours, and as a small number of men could handle this amount of material, equipment would not have been needed had it been available.

With the great increase in the size of the units, conditions became more and more difficult. The gangs of men required to feed a furnace grew to be large. The work was hard and it was very difficult to maintain full gangs. It must be borne in mind that no delays could be tolerated. A short suspension of filling would let the furnace get "down," which would probably be reflected in poor iron or in some other form of bad furnace work the next day.

More than 80 per cent. of the iron produced in the United States is made from ores mined in the Lake Superior region and transported wholly or partly by water to the points of consumption. Navigation on the Great Lakes is open nominally seven months, but actually only about six in each year. Therefore furnaces which derive their ore supply from this region are under the necessity of having on hand a six months' stock of ore at the close of navigation. If the furnaces are some distance removed from the receiving port of the ore, the latter may be stored on the docks or at storage yards maintained by the railroads. But the best practice increasingly tends toward shipping the ore directly to the furnace plant, and storing it in an ore yard devoted to that exclusive purpose, and not infrequently equipped with powerful and expensive machinery for putting the ore into the stock pile and reclaiming it as needed throughout the year.

A plant of four furnaces, of five hundred tons daily capacity, is not a large one as furnace plants go to-day, but such a plant consumes four thousand tons of ore per day, or 1,460,000 tons per year, and all of this must be stored during six months or less and half of it, say 750,000 tons, must be reclaimed from storage during the six months which includes the winter weather, and principally in the severe climate which characterizes the central district of the United States. As it is characteristic of the Lake Superior ores to carry from a minimum of five or six, to a maximum of twenty-two or twenty-three per cent. of moisture, with an average of ten or twelve per cent.; and as this moisture is not combined with the ore, but only held by it in the shape of moisture, these great stock piles freeze to a depth of several feet, and the ore being soft and plastic, like clay or sandy loam in most instances, the frozen mass is exceedingly hard. Machinery well able to handle the material in its unfrozen condition would be unable to stand the service on frozen ore for the briefest period. This adds another very severe condition which must be met in handling the raw materials for iron manufacture in a preponderating portion of the business.

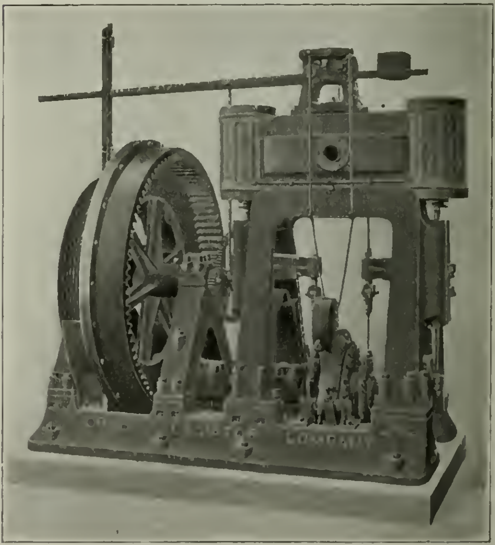
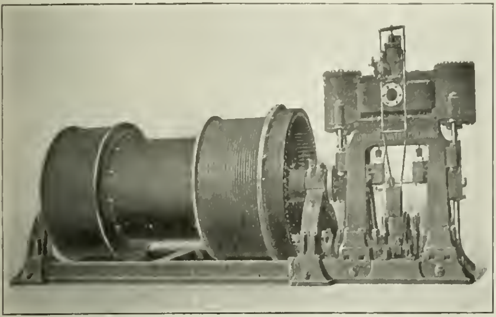


FIG. 1—STEAM-DRIVEN BLAST-FURNACE HOIST FOR FURNACE WITH VERTICAL HOIST TOWER

### Power Hoisting

The first change from the primitive arrangement I have described was the introduction of power hoists for taking the material to the top of the furnace. These were of two kinds, vertical and inclined, but irrespective of this in the majority of cases a platform was used onto which the barrows were rolled by men at the bottom. The platform was then hoisted, whether vertically or on an incline was a matter of detail, and men at the top, known as the top fillers, took the barrows off the car, distributed them around the top of the furnace and dumped them.



FIR. 2—STEAM-DRIVEN HOIST FOR A SKIP-FILLED FURNACE

The introduction of power hoisting as a substitute for the bridge method of bringing the material to the top of the furnace was necessitated by the increase in the height of the furnace from some twenty-five or thirty feet to fifty, sixty and seventy feet. No hill could be found steep enough and high enough to lend itself to filling purposes for furnaces of such heights.

The operation of filling being continuous, and the need for capacity growing rapidly after the introduction of power hoisting, double acting hoists were introduced very early and are used almost universally, with certain exceptions to be noted later. By this means the platforms, cars and filling barrows balanced each other on the ascending and descending trips, leaving only the useful load of the charge to be hoisted. This effects the saving of a great deal of power, and permits the use of much smaller hoisting apparatus.

Many styles of hoisting apparatus were tried in the early days of power hoisting, hydraulic, pneumatic, water balance and various types of engine driven hoists were used. Nevertheless this was one of the earliest parts of the equipment to become standardized, and for many years there has been used a very simple type of vertical two-cylinder engine, with cranks at right angles, and the engine shaft geared to the rope drum with either a single or double reduction gear. These engines are not fitted with a link like that used for reversing locomotives and other high grade engines, but are reversed by running the steam in opposite directions through their ports. One set of openings constitutes the inlet when running in one direction and the exhaust in the other.

In order to operate successfully on this system the valves must be set without "lap" or "lead," the eccentrics being exactly at right angles to the cranks, so that the steam follows the piston full stroke, and is not used expansively, even to the slightest degree. As a result these engines are very extravagant of steam, using about one hundred and twenty pounds per horsepower per hour as against twelve to twenty pounds for ordinarily good engines in power stations.

In the last ten or fifteen years there has been a growing tendency to avoid this great waste of steam by the use of motor driven hoists, these obtaining their current from generators in the power station, driven by an engine using not much more than a tenth of the steam per horsepower that is required for the hoisting engine.

There are, however, problems of control which have had to be met and which have proven rather difficult. With the large masses of material now handled it is very important that the operation of hoisting be started and stopped gradually to eliminate the excessive stresses which would otherwise arise. These problems have been solved successfully with the steam hoisting engine by the use of supplementary throttles thrown in and out of operation by a cam traveling at a suitable reduced speed. In order to accomplish the same result with the electric hoist, sliding contacts and a great multiplicity of switches were at first considered necessary, so that the switchboard for such an apparatus was very large, elaborate and expensive.

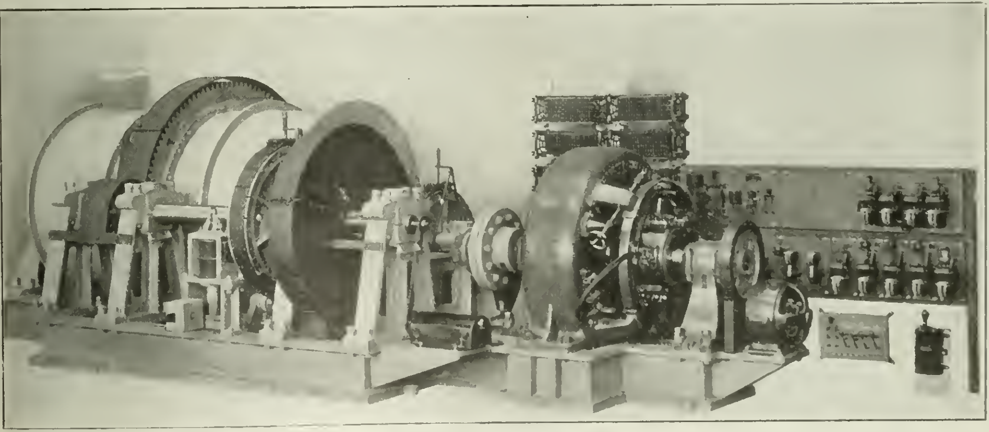


FIG. 3—ELECTRIC HOISTING APPARATUS

This problem has, however, been worked out successfully, and such electric hoists are now articles of regular manufacture, as are the steam hoisting engines previously mentioned. Fig. 1 shows a modern steam-driven blast furnace hoist for a furnace with a vertical hoist tower, where the ropes are led by guide sheaves from the tops of their respective cages to points vertically over the opposite sides of the drum, so that when the rope from one cage is winding up that from the other is unwinding. The cages are thus balanced through the hoisting drum rather than directly. This hoist is built by the Otis Elevator Company.

Fig. 2 shows a steam-driven hoist for a skip filled furnace, in which there are two distinct drums, separated by a suitable distance horizontally so that the center of each drum shall be in the central plane of its skipway. This will be more fully explained in dealing with skip hoists. This hoist is also built by the Otis Elevator Company.

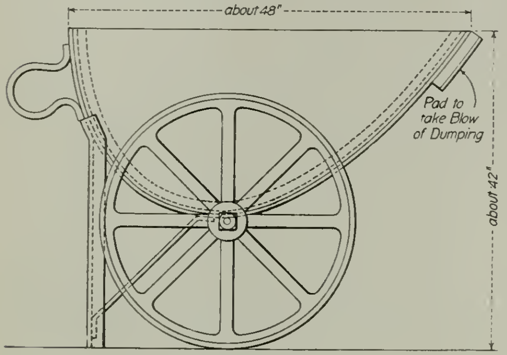


FIG. 4—ORE BARROW

Fig. 3 shows an electrical hoisting apparatus with its switchboard, built by the Lidgerwood Manufacturing Company. It will be seen that the rope drums in this are the same type as that shown in Fig. 2, this also being for a skip filled furnace.

### Hand Filling and Filling Barrows

The system of handling raw materials in barrows was almost universal until the middle of the decade beginning in 1891. Many attempts had been made to eliminate at least a portion of the labor required for handling the great quantity of material needed as furnace outputs increased. But these were either mechanically unsatisfactory, or else their effect upon the work of the furnace was detrimental, in many cases disastrous. The reasons for this, in so far as they are known, will be given at some length in the chapter on operation; suffice it for our present purpose to say that probably ninety-five per cent. of all the iron made for thirty or forty years previous to the time mentioned was made from raw materials handled in filling barrows. These are so widely known that it seems almost unnecessary to describe them, but for logical completeness a brief description may not be amiss.

These barrows are universally two-wheeled, with at least one of the wheels loose on its axle to enable them to turn corners easily, and provided with stout legs on the rear end, which hold them level when standing. They are dumped by tipping forward on the axle, the wheels remaining stationary when they come against the dumping ring on the top of the furnace. On account of the vast difference in the specific gravity of coke, and ore, or limestone, a different type of barrow is generally used for handling these two kinds of materials. The ore and limestone barrows are as shown in Fig. 4, and the coke barrow as shown in Fig. 5. The latter are much larger and provided with a door in front, which is held shut by a latch, this latch being released from the rear a moment before the barrow is dumped. This construction is used in order to obtain a reasonable capacity for so light a material as coke. These barrows are built of steel plate, very substantially riveted together throughout, as they are subjected to continuous service and particularly to very heavy shocks when they are dumped, the nose of the barrow dropping forward on the iron dumping ring with a hard blow.

In ordinary practice the barrow weighs about eight hundred pounds, and will carry a load of about fifteen hundred pounds of ore. Ordinarily they are not loaded quite as heavily as this, as they then become too difficult for one man to handle, even on good floors.

The capacity of the coke barrow is roughly one-half as much by weight, so that the same number of barrows of coke as of ore are required per charge, the ore charge weighing normally about twice as much as the coke charge.

The physical labor involved in wheeling the barrows from the stock piles to the foot of the hoist is in ordinary practice roughly the same as filling them by hand. Therefore to dispense with hand shoveling, and continue the use of filling barrows, is only a half solution of the problem of eliminating manual labor in filling. Moreover, when the barrow system of filling is used it is necessary to have always one, and frequently two or even more men on top of the furnace to take the barrows from the cages to the furnace top, dump them and return them.

This labor is more expensive, man for man, than the labor at the bottom of the furnace, because it does not pay to have a foreman supervise the relatively small number of men required, and yet the operation of dumping, with which they are entrusted, is of the utmost importance, and slight variations in the method of dumping with hand filling, more frequently than any other cause, derange the work of the furnace.

For this reason it is necessary to secure a higher grade of labor for at least one of these top fillers by paying higher wages. Another reason for paying higher wages is that the men are under a certain liability to be overcome by the furnace gas when remaining for a long time on top. It is impossible to make the bell absolutely tight and keep it so all the while. Small particles of stock lodge on its seat and hold it open by an almost microscopic amount until the next dumping, when they are swept off, but very likely replaced by similar particles in some other location, so that the bell seldom shuts absolutely tight.

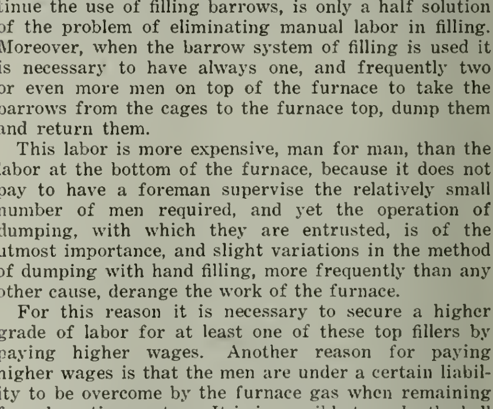


FIG. 5—COKE BARROW

There are other points at which gas can escape, such as the test rod hole and various other places through which the gas will find its way in quantities frequently too small to be visible, but nevertheless tainting the atmosphere sufficiently to overcome men exposed for a long time to this poison, even in this dilute state.

This possibility of accident, though real, is small, and fatalities due to the ordinary course of filling almost unknown, nevertheless it is sufficient to necessitate a higher scale of wages.

For all these reasons the elimination of manual handling of the stock from the bins to the furnace top was the goal of furnace builders for many years. But as the manager of the furnace was rarely the engineer who built it, he looked at the matter from a different point of view, and the many failures recorded to the credit of mechanical filling made managers very chary of risking their success and reputation in operating such plants.

### The Duquesne Revolution

In the middle of the decade beginning 1891, furnace outputs had become as high as 400 tons per day in regular operation. The crews necessary to fill them by hand labor using these barrows were tremendous. Then, too, the capacity of the platform hoists had almost reached their limit, and it became almost a matter of physical impossibility to fill furnaces for any greater output by this means. Accordingly when about 1895 the Carnegie Steel Company decided to build at Duquesne a plant of four furnaces with a capacity of six hundred tons per day each, these furnaces being about twenty-one feet in diameter by one hundred feet high, they determined to strike out on new lines and eliminate altogether hand labor for filling.

M. A. Nieland was then chief engineer of the Duquesne works, and he designed what has since become one of the standard methods of mechanical filling, commonly known as the bucket system. This was a success mechanically and metallurgically and was the beginning of a revolution in the construction and operation of blast furnaces. It having been demonstrated that mechanical methods could be made to operate successfully on so large a scale, and with an enormous saving of labor, other methods to achieve these ends were soon devised, and as a result it is probably safe to say that three-fourths of all the iron now produced is made at furnaces mechanically charged.

The plan of eliminating labor wherever possible was carried out in all directions at this plant, whose mechanical equipment throughout was the best obtainable at that time. Thus the construction of this plant marks a distinct epoch in the history of the blast furnace in the United States.

### The Delivery of the Stock to the Furnace

Returning now to the matter of handling raw materials from the stock piles to the barrows, this, as has already been stated, was at first done exclusively with shovels, but when the introduction of railroad transportation replaced the delivery of the raw materials to the plant by team, it was soon found necessary to elevate the tracks on trestles to facilitate unloading the material from the cars.

The cars were at first of the flat-bottom type, but very soon hopper-bottom cars, the prototypes of those in use to-day, were introduced. For these trestles became absolutely necessary. It was then a short step to install bins underneath these trestles, into which the materials could be dumped directly from the cars, and from which, in turn, they could be drawn directly into filling barrows without hand shoveling.

This eliminated probably fifty per cent. of the labor of filling, and, considering the great returns which the investment in bins pays in the form of labor saved, it is surprising that their introduction was not more rapid, but at the time of the Duquesne revolution many plants which considered themselves modern and well equipped were still handling their raw materials largely or wholly by hand. Since that time, however, the use of bins in large plants has become practically universal.

It will be seen that the order in which we have followed these developments, in the hoisting of the material, in its transportation from the stock house to the furnace, and in its delivery into the means of conveyance in the stock house, is the reverse of their logical order. But this is the way the development actually occurred chronologically, and to consider them in this order is perhaps justified on this account.

In discussing the development of mechanical filling, it is now necessary to revert to the subject of the delivery of the ore, for so large a part of the ore in this country is transported by water, and only during a relatively brief season, that this has had profound influence, not only on the handling of the ore at the ports of receipt, but also at the blast furnaces, because the machinery which was developed for unloading the boats was found almost equally valuable, with slight modifications, at the blast furnace also.

The conditions of water transportation imposed two difficulties on this traffic. First, the difficulty of unloading ore from the holds of vessels well below the water line, lifting it to a sufficient elevation and transporting it to a sufficient distance to enable it to be deposited in a stock pile, and, second, the necessity of doing this in the least possible time.

As has so often happened in industrial history, the solution of these difficulties resulted in an eventual benefit of enormous importance to the industry concerned. Less than a generation ago, boats of two or three thousand tons, the largest then in service on the Great Lakes, could be unloaded only by shoveling the ore by hand into tubs, hoisting these with ropes, dumping them on the wharf and then wheeling the ore up an incline onto the stock pile. This took vast quantities of labor, and as the men required physical stamina and endurance to stand up under this work there was a limited market from which this labor could be drawn. As a consequence the supply was always below the demand. This resulted, as it always does in such cases, in making the men arrogant, unreasonable and difficult to manage to a very high degree. This, in conjunction with the high wages it was necessary to pay them, made the unloading process very tedious and expensive.

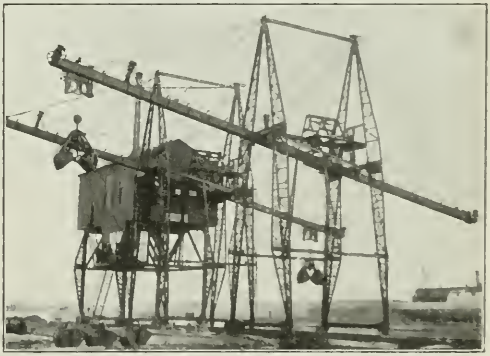


FIG. 6—BROWN HOIST FAST PLANT

During the decade beginning 1881, Alexander E. Brown began to apply his brilliant engineering ability to the problem of performing this work mechanically. His efforts met with the highest success, and other engineers, following in the path which he had blazed, developed still further the possibilities of mechanism in such work. So that while in 1885 it took about three days to unload a vessel of three thousand tons, and cost about twenty-five cents per ton, it is now possible to unload vessels with machinery designed for this purpose in a shorter time than their cargo can be spouted into them from bins on the docks at the Upper Lake ports, and at a total cost for labor, power, maintenance, interest and amortization on investment of not over four cents per ton.

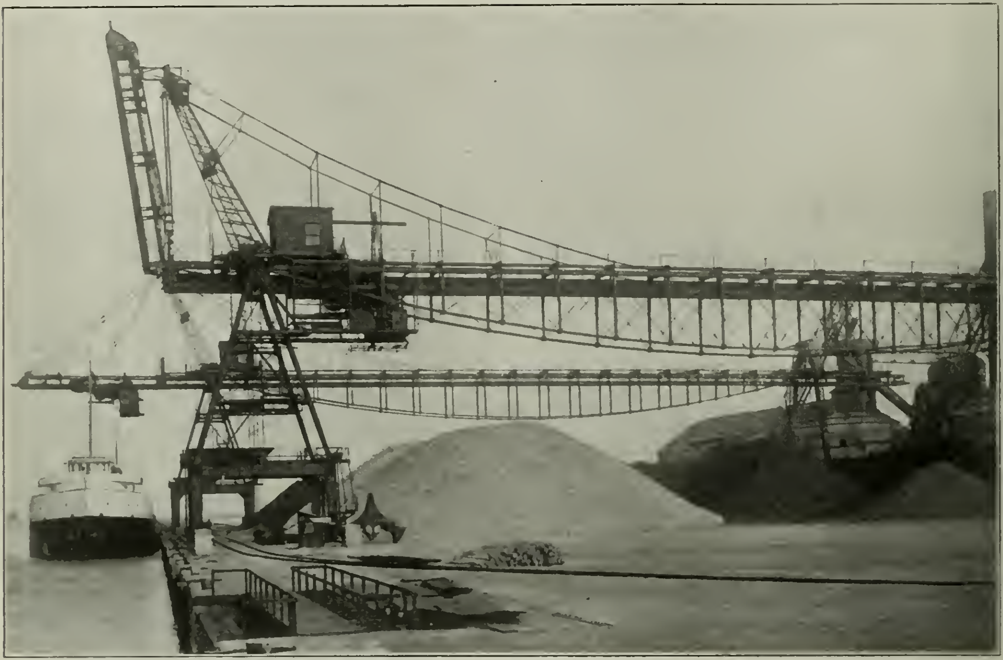


FIG. 7—BROWN HOIST TRAVELING BRIDGE

In the summer of 1912 a steamer containing something over thirteen thousand tons docked at 1:15 and was unloaded and had cleared for the Upper Lakes at 4:35 on the same afternoon. Three hours and twenty minutes to remove thirteen thousand tons of material. Probably not over twenty-five men were employed on the task all told, so that the labor cost was almost negligible. This was a record at that time, though it may have been beaten since.

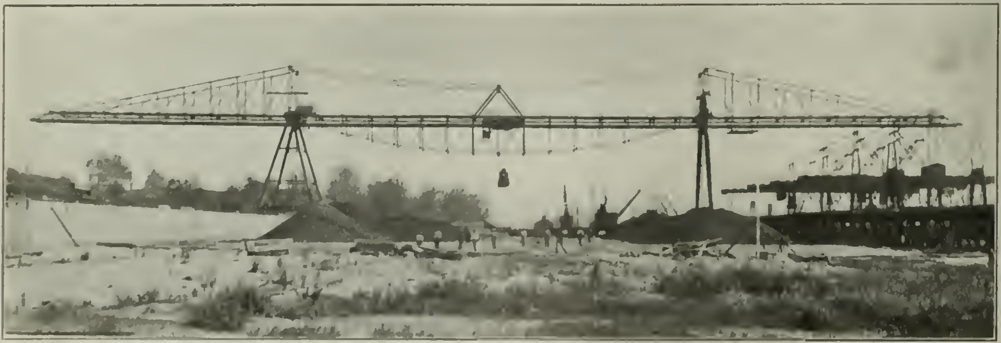


FIG. 8—BROWN HOIST BRIDGE WITH FAST PLANTS IN BACKGROUND ON THE RIGHT

### Ore Handling Machinery

On account of the vast influence of the machinery developed for unloading vessels on the problem of stocking and reclaiming ore at the blast furnace, it will not be amiss to illustrate here some of the equipment by which these results are achieved. Fig. 6 shows a fast plant, designed and built by the Brown Hoisting Machinery Co., and may be considered the legitimate development of the first mechanical equipment built for this purpose by the same company twenty-odd years ago.

Where greater stocking capacity is required than the fast plant trolley travel will cover, traveling bridges are used, as shown in Fig. 7. In these the trolley travels on a straight member of the bridge, which is carried on the two traveling trestles shown. One of these runs on a double set of rails near the dock front, spanning one or more standard gauge tracks, the other on a single rail at the rear end. The bridge is pivoted to the trestles or legs so that it can be slewed at a considerable angle. The runway is carried beyond the line of the traveling legs on cantilevers, the outer one of which is hinged so that it can be raised up out of the way to permit the bridge to pass the spars of vessels. Equipment of this type is used particularly where the furnace plant is at the lake front. Where the stocking capacity required is so great as to necessitate the employment of bridges and where rapid unloading capacity for the vessels is also required a combination is made of the two styles of equipment. Several fast plants remove the ore from the vessels and dump it within reach of the bridge, which picks it up again and stocks it as required, as shown in Fig. 8. This system will be described more in detail in conjunction with the Hoover & Mason and the Wellman-Seaver-Morgan apparatus.

Fig. 9 shows in diagrammatic style a Hoover & Mason unloading and stocking apparatus. This consists of two distinct parts. First, a gantry crane with cantilever extensions, one side of it is carried on wheels running on the top of the left hand wall of the ore trough, the other on wheels running outside the railroad tracks close to the dock face. This gantry supports a horizontal runway for a trolley from which hangs a grab bucket, shown in its open position after descending into the ship's hold, at the extreme left.

The method of suspension of this grab bucket is such that it may be rotated at any angle, for the reason that it can only go through the hatches when turned with its long axis parallel with the hatch. But in order to reach out beyond the hatch line and get the ore between the hatches, it is necessary for it to be able to rotate so that its long axis is at right angles to the line of the hatch.

The operation of unloading is carried on as follows:

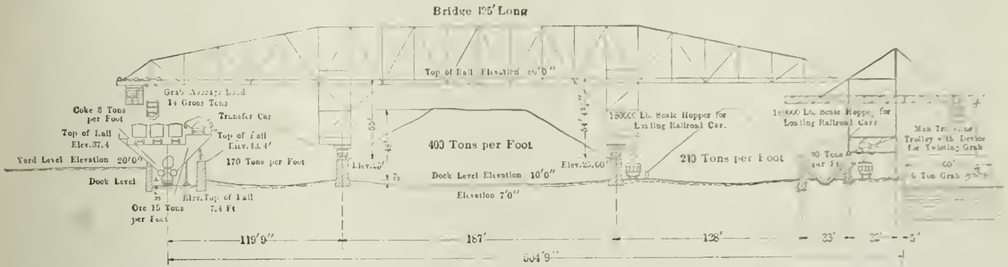


FIG. 9—HOOVER AND MASON UNLOADING AND STOCKING APPARATUS

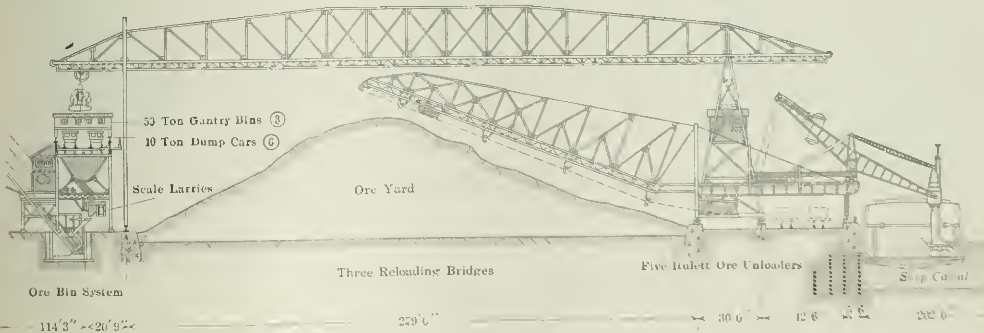


FIG. 10—HEWLETT UNLOADER IN CONNECTION WITH ORE BRIDGE

The grab bucket is lowered into the ore, closed, turned parallel with the hatch and elevated to a position alongside the cab hanging from the trolley. The whole trolley is then traversed back to one of two positions and there dumped. The first position is just to the left of the center of the gantry; the other on the left-hand extension of the cantilever outside the gantry. In the first position it discharges into a small hopper and from there the ore is loaded into railroad cars for direct shipment. In the second case it discharges into a concrete trough, from which the ore is reloaded by the second portion of the apparatus.

This consists of a traveling bridge one hundred and seven feet from center to center of supporting legs, with cantilever extensions on each end, running its total length up to four hundred and ninety-five feet. This bridge is also equipped with a trolley and grab bucket, the latter being of more than twice the capacity of the one which goes into the ship's hold, which is of six tons' capacity, the one on the main bridge being of fourteen tons.

This bridge travels on tracks laid on concrete walls, raised up well above the level of the ore yard, so that the ore will not run down on the tracks even when the yard is filled about to its capacity. The trolley and grab bucket on the main bridge use the ore in the trough as a source of supply, and taking it out of this trough carry it back to any one of the three piles under the three portions of the bridge and there dump it.

The drawing is so plain as not to need very much detailed explanation. Means are provided whereby ore may be shipped out by rail from two or three points. At the lefthand end of the drawing is the bin system for the furnace itself, this plan having been prepared for a furnace plant located just back of the dock line on the lake front, but a plant of the same general type would be used if the ore were merely stored in the yard and shipped out as required through the winter.

It will be seen that the gantry unloaders are relatively inexpensive as compared to the main ore bridge, and it is therefore commonly possible to have five or six of these all working on a vessel at the same time, and delivering their ore into the concrete trough. The large bridge follows these and keeps the trough sufficiently clean for them so that they are free to dump in it when they move, as required by the contents of the hatchways, etc., thus the unloaders can be devoted to the purpose of unloading without much consideration of the question of ultimate disposal.

The bridge, on the other hand, is an extremely expensive apparatus, and, being many times heavier than the gantries, cannot be moved back and forth as they are, though it can move with sufficient ease to follow them at intervals and keep the ore trough free for them. By this combination rapidity of unloading is secured without excessive expense for long-span bridges.

The latest developed apparatus for unloading is that brought out by the Wellman-Seaver-Morgan Company, and named for its inventor, Mr. George H. Hewlett, the Hewlett unloader. A diagram showing this in conjunction with an ore bridge is shown in Fig. 10. This apparatus is equipped with a grab bucket, a modification of the old clam shell bucket, but with two important differences from the machines of Brown and Hoover & Mason. First, the bucket, instead of being suspended by ropes, is carried at the lower end of a rigid column.

Second, the grab bucket, instead of having both jaws symmetrical, as is the case with the suspended buckets, has one jaw provided with a horizontal traversing motion, so that after it is opened, with the jaw swung up into the vertical position, it can be extended several feet horizontally, and by being lowered into the ore in this position serves to pull the ore toward the center of the bucket with a motion exactly like that of a gigantic hoe.

The operator rides in a small chamber in the stiff leg which carries the grab bucket. This is raised and lowered by a walking beam supported on trunnions, which are carried on a truck provided with means for traversing itself back and forth in the plane of the walking beam, that is in a plane at right angles to the dock line. The track on which the truck or trolley moves is carried by a traveling gantry bridge running on a pair of tracks, one close to the face of the dock, the other some distance inshore, as shown. The column, or stiff leg, which carries the grab bucket, is held in a vertical position irrespective of the angle of the walking beam by a parallel motion.

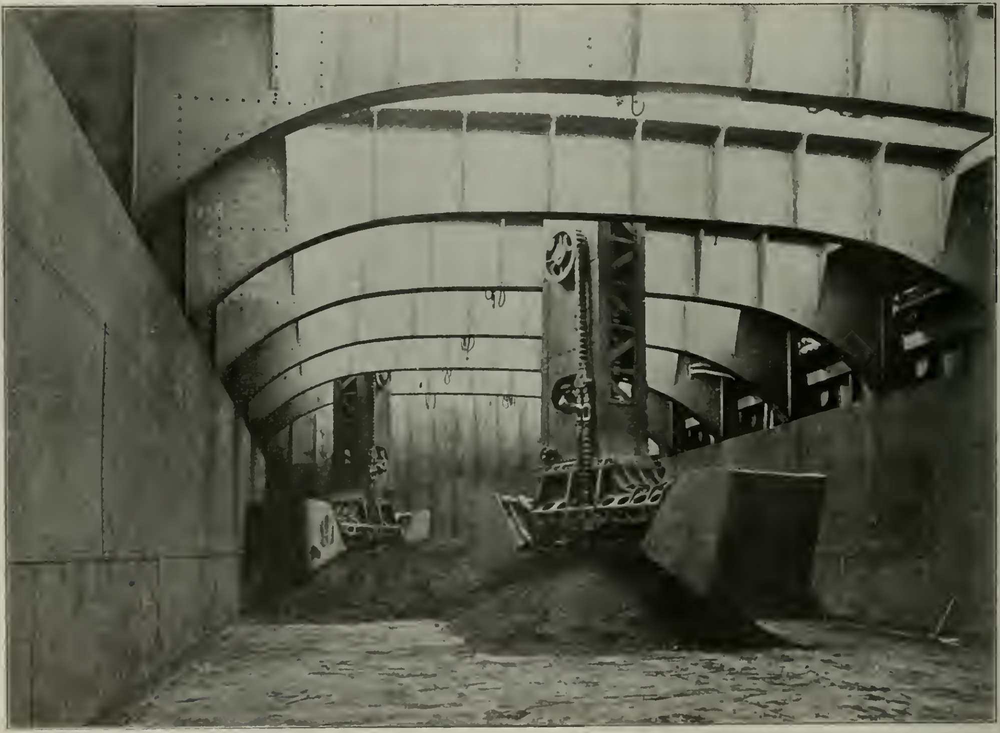


FIG. 11—HOLD OF VESSEL WITH THE GRABS OF TWO HEWLETT UNLOADERS AT WORK CLEANING UP THE FLOOR

The grab bucket and part of its load are counterweighted at the opposite end of the walking beam to reduce as much as possible the amount of power required for raising it and to facilitate its control.

In operation the walking beam is tipped to lower the grab bucket through the hatch, the stiff leg is then rotated to throw the longer arm of the grab bucket into any desired position, and if only a small quantity of ore remains in the hold at this location, the long arm of the grab is then used to pull several piles of ore together so as to make an approximately complete load for the grab, which it then picks up, so that it always goes up from the hatch loaded to its capacity. This capacity is very large. For a time ten tons was considered to be the limit, but several machines are now in successful operation with fifteen-ton grabs.

After the grab bucket is raised out of the hold the truck which carries the walking beam is traversed inland until the grab comes over to one of two or three alternative points of discharge. Two of these deliver directly to railroad cars on tracks running between the legs of the Hewlett. The other is a small retaining hopper running on wheels which travels on the landward cantilever extension of the machine.

In case stock piling is to be done the grab bucket discharges into this traveling hopper, which then runs out on the cantilever and discharges on the stock pile. If more stock pile room is desired than can be reached by the cantilever, then a traveling bridge is brought into play precisely as described for the Hoover & Mason apparatus. The photograph (Fig. 11) on the preceding page shows the hold of a vessel with the grabs of two of these unloaders at work cleaning up its floor. No hand work has been done in this hold, yet it will be seen that the floor is almost as clean as if it had been swept, except for the piles on which the buckets are still operating.

Fig. 12 shows one of these Hewletts complete, though not provided with a long cantilever extension, but with a bridge in the background to do the stock piling.

Fig. 13 shows three Hewletts working on a vessel with the piles of ore at their landward ends, and the outer end of the bridge, which is making the stock pile, in foreground. Fig. 14 shows four Hewletts working on a steamer with stocking bridge behind them.

The absolute control of the mechanism which the operator exercises by having it rigidly supported instead of swung, and by the fact that he himself is immediately upon the bucket and can see to control its movements accurately, gives this machine advantages in handling bulk cargoes not enjoyed by any other type of machine. One of these advantages is that this accurate control of the grab bucket enables the operator to avoid striking the bottom of the hold severe blows

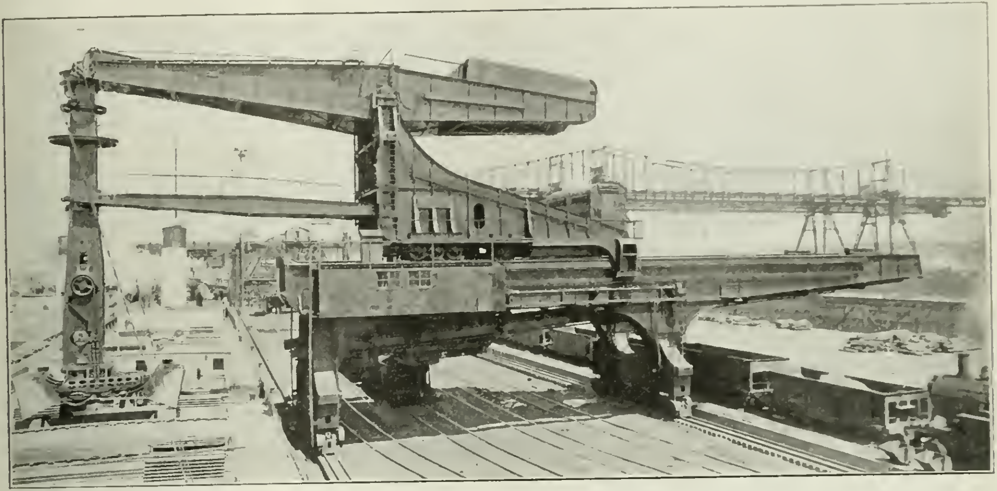


FIG. 12—HEWLETT COMPLETE

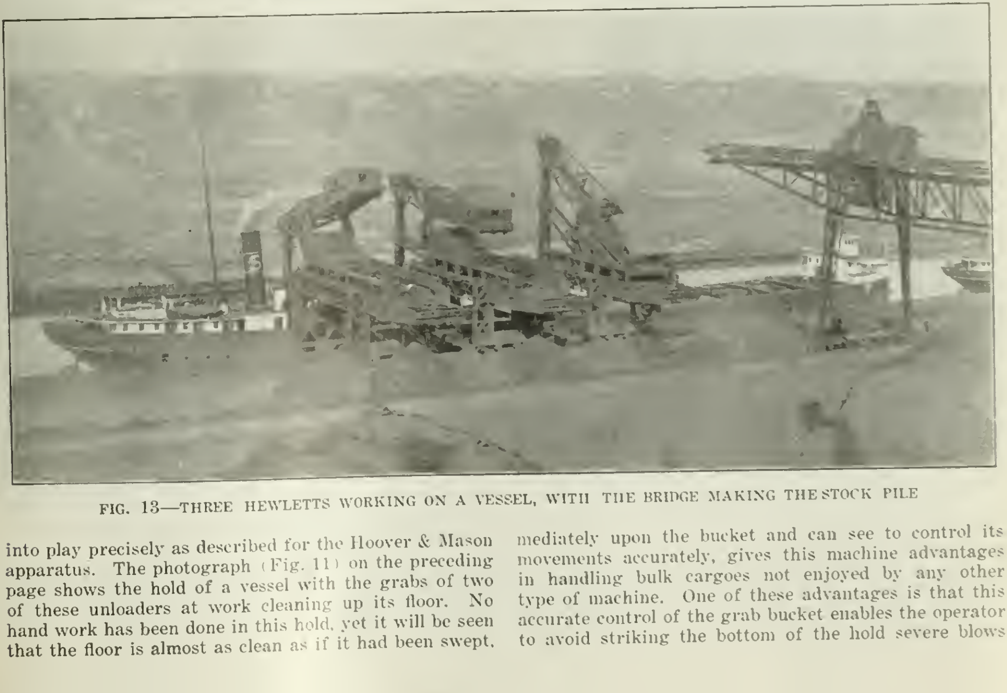


FIG. 13—THREE HEWLETTS WORKING ON A VESSEL, WITH THE BRIDGE MAKING THE STOCK PILE

with the bucket, as frequently happens with older types of apparatus.

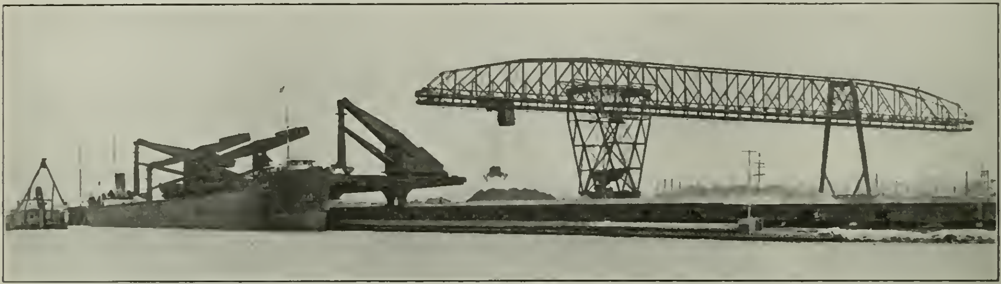


FIG. 14—FOUR HEWLETTS WORKING ON A STEAMER WITH THE STOCKING BRIDGE BEHIND THEM

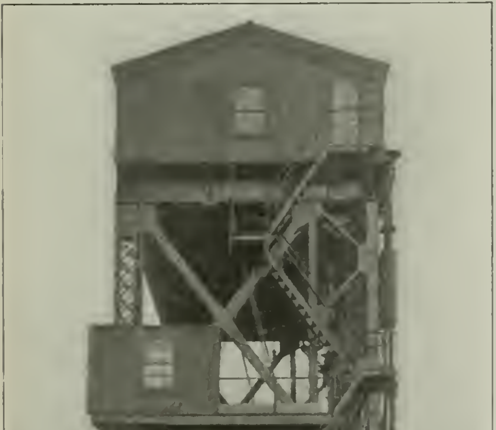


FIG. 15—CAR DUMPER

In reclaiming the ore from the stock pile for use at the furnace the operation is very similar to that of stock piling. But in this case also it is necessary to provide some more easily movable means than the bridge itself for carrying the ore from the bridge to the point of consumption. It will be readily understood that there are always several, and maybe very many varieties of ore in the stock pile, and on account of the great difficulty in keeping these separated, the same kinds of ore are always piled together, so as to make the individual piles as few in number and as large as possible.

When any given kind of ore is desired for the furnace therefore, the ore bridge is moved over this pile and the grab bucket set to work on it. At the furnace or discharging end of the bridge it spans at least one and generally several tracks. Each traverses the tops of the bins from which the immediate supplies of raw materials are drawn. On one or more of these tracks runs a drop bottom transfer car, generally driven by an electric motor under the control of its operator. Such a car can carry fifty or more tons of material at a trip. The distance from the bridge to the bins where the ore is needed being only a few hundred feet, it can readily run back and forth from bridge to bins, and serve the bridge about as fast as the latter can reclaim the ore.

Many variations of this general plan of operation have been worked out. In some places removed from the Lakes the ore is received in drop-bottom cars, which are dumped from trestles, and the ore then reloaded as needed, either by taking the furnace-filling equipment direct to the stock pile and there loading it by hand, or by reloading the ore with clam-shell buckets, operated by locomotive traveling cranes, loading it into cars on the trestles, taking these to the bins and dumping

### Car Dumpers

Plants removed from the lake shore must, of course, receive their ore by rail, and the enormous quantity to be handled in the relatively brief open season has made desirable in some cases a greater speed in dumping than can be secured even with the modern drop-bottom type of ore car.

To meet this condition an apparatus called a car dumper has been applied at some plants. This apparatus has been built in two styles, stationary and moveable. The moveable type is greatly to be preferred, because when a stationary dumper is used some style of transfer car is needed to carry the ore from the car dumper to the stocking bridge, which must stand in the location at which it is desired to stock the ore. With the traveling type of car dumper this is not necessary. The car dumper is moved along on its own tracks, just in front of those carrying the rear end of the bridge, and the car when dumped delivers the ore to the exact spot where it is most easy for the bridge to pick it up.

The general appearance of the car dumper, just back of the retaining wall of the ore yard, with a car standing in it, is well shown by the photograph, Fig. 15.

This apparatus can easily dump one hundred and fifty cars per day of ten hours, and most of the cars used in this service carry about fifty-five gross tons. It will be seen that the amount of material which can be handled through it in a given time is enormous.

In spite of the enormous capacity and great efficiency of these machines for the purpose intended, it may be doubted whether very many plants require the dumping of so vast a quantity of ore in a given time as to compensate for the heavy interest charges on the investment involved in one of these machines, especially in those cases where the ore yard is provided with elevated tracks from which dumping may readily be done.

In such a case the amount of labor involved in dumping the desired number of cars of ore from modern drop-bottom cars is not great, and its cost in all probability does not offset the interest and amortization charges on a car dumper.

At those plants in which the location of the ore yard is relatively high, and it is impractical to provide an elevated dumping trestle, the car dumper undoubtedly furnishes the best solution of the problem when considerable tonnages are to be handled.

### Power Used

Various kinds of power have been used from time to time for operating the various types of ore-handling machinery, described and illustrated above, but it is safe to say that at the present time no power is seriously considered for this service under any ordinary conditions except electricity. This is supplied either from trolley wires or from sliding contacts, like a third rail, parallel to the track, as the circumstances may require.

Whether alternating or direct current is to be used is a matter of some discussion among experts in this field, but in the majority of cases direct current at 220 volts is used, because of the superiority of control which the direct possesses over the alternating, and because with this kind of current dynamic breaking can be used in addition to mechanical brakes for retardation of the moving parts. This can not so easily be done with alternating current.

Each plant presents ore-handling problems of its own, and in each case the problem must be worked out on the basis of the conditions to be met. Enough has been said to give a substantial idea of the general outline of the operation.

*(To be concluded)*

## Synopsis of Recent Chemical and Metallurgical Literature.

### Iron and Steel

**Pulverized Fuel for Metallurgical Furnaces.**—Supplementing an abstract on this subject in our last issue, we give a synopsis of a paper by Mr. JAMES LORD, published in the October, 1913, number of the *Proceedings* of the Engineers' Society of Western Pennsylvania. Mr. Lord gives the experience of the American Iron & Steel Manufacturing Company, Lebanon, Pa., of which he is president. This company has been using pulverized fuel at its plant, in experimental and practical ways, for the past ten years. "From the first it was apparent that its economical use depended upon the absolute control of the feed by the burner. This having been accomplished, we have applied it to over 100 furnaces of various types, such as those for puddling and heating, and of smaller sizes for re-heating nut, bolt and spike bars. It has proved to be a commercial success for all the above purposes, and the experience of ourselves, and others working along similar lines, shows that it can be used with equal economy for basic open-hearth steel furnaces, either with or without checker work. Our experience in the use of this fuel over a number of years has been so satisfactory and so economical that we are now largely increasing our installation, and are about to apply it to open-hearth steel furnaces."

Mr. Lord gives the following requirements for success with pulverized fuel: Both free and combined moisture in the coal must be less than 0.5 per cent; it must be pulverized fine enough to permit 95 per cent to pass a 100-mesh screen, and over 80 per cent to pass a 200-mesh screen; the delivery to the furnace must be controlled by the burner; the coal should have a high percentage of volatile combustible matter, not less than 30 per cent; the sulphur should not exceed 1 per cent.

The following figures show the pounds of fuel necessary to produce 1 ton of puddled bar, made from gray forge pig iron:

| Furnace No. | April | May |
|---|---|---|
| 23 | 1362 | 1318 |
| 24 | 1164 | 1277 |
| 25 | 1271 | 1472 |
| 26 | 1371 | 1362 |

The average for the same months on a lower grade of pig and cast scrap was 1239 lb.

The cost of preparing pulverized fuel during 1912 was as follows:

| | Cents per gross ton coal produced |
|---|---|
| Fuel | 0.034 |
| Repairs to buildings | 0.002 |
| Operating | 0.145 |
| Power (steam and electric) | 0.221 |
| Repairs, machinery and equipment | 0.200 |
| Total | 0.602 |

Analyzing the last item we find repairs which should be charged over a period of eight years, so that the total cost did not properly exceed 50 cents per ton of pulverized coal produced during 1912. If transmission is omitted, the cost of preparation would not exceed 40 cents.

In heating iron piles for rolling, the following quantities (pounds) of coal were used to produce a gross ton of rolled bars. On steel billets the amount would be one-third less:

| Mill | April | May |
|---|---|---|
| 12-in. Central | 516 | 528 |
| 12-in. West | 544 | 570 |
| 16-in. Central | 519 | 523 |

The paper of Mr. Lord was widely discussed by many members of the society, who gave their experiences with pulverized fuel at different places.

### Gold and Silver

**Treatment of Gold-Bearing Scheelite in New Zealand.**—The scheelite deposits of New Zealand are important sources of tungsten. One of the mines, the Golden Point, has been operated for twenty-five years, and is the principal producer. The ore contains gold as well as tungsten, and its treatment is interesting, as outlined by Mr. CYRIL W. GUDGEON in the *Australian Mining Standard* of Nov. 13, 1913.

The ore is sorted in the mine into first and second grades. On reaching the mill, the first grade is again hand-sorted, yielding from 1 to 2 tons per month of a product containing from 60 to 65 per cent $WO_3$, which is marketed. The reject from the hand-sorting is crushed and jigged, producing a concentrate of 60 per cent $WO_3$ and a tailing which is added to low-grade ore. The low-grade portion is crushed in stamps through 30-mesh screens, and run over amalgamated plates to recover some gold. The value of the ore usually averages $3.60 in gold, and of this $1.55 is caught on the plates. After amalgamation the pulp is classified and concentrated on Wilfley tables. The products are (1) a low-grade tungsten concentrate containing 30 per cent $WO_3$ and 60 per cent $FeS_2$; (2) slime tailing which is discharged, and (3) sand tailing which is leached with cyanide solution. The recovery in the cyanide plant is $1.30 per ton of ore. The low-grade tungsten concentrate amounts to only $\frac{1}{2}$ to 1 per cent of the ore milled, and contains about $2\frac{1}{2}$ oz. gold per ton. This material is then dried and roasted and subjected to magnetic separation for the removal of pyrite. The tungsten product runs 60 per cent $WO_3$; the pyrite contains from 5 to 6 oz. gold per ton. The costs of milling 1998 tons of ore, in cents per ton, were: Breaking and jigging, 3.8; stamping, 55.8; concentrating, 8.0; general, 7.6; cyaniding, 26.6; magnetic separation, 36.0; total, $1.378.

### Analysis and Assaying

**Lead Determination at Broken Hill.**—The *Proceedings* of the Australasian Institute of Mining Engineers, No. 10, 1913, contains an interesting report of the assay sub-committee on an investigation of methods used for analyzing and assaying Broken Hill ores and concentrates. The committee's investigations covered methods of estimating lead, zinc and silver. The samples were prepared by drying at a temperature not exceeding 200 deg. C., and then grinding to pass a 100-mesh screen. The sample thus obtained was rolled on a cloth and finally brought into a cone and flattened. Portions for assay were dipped from the mass with a spatula.

*Lead.*—The methods considered were (1) the molybdate, with two modifications, (*a*) filtering the lead sulphate hot and (*b*) filtering it cold; (2) the chromate, and (3) the gravimetric, weighing as lead sulphate. The general principles of these methods are all well known. Two methods of standardizing were tested, using metallic lead and lead sulphate. For the case of hot filtration in the molybdate method, lead sulphate cannot be used for standardizing, as similar conditions would not obtain in treatment of ore and standard. The accompanying table shows the results of tests made by different assayers (A, B, C and D), with all methods and modifications, determining lead in various ores and concentrates.

*Table A*

| Ores | Ammonium-Molybdate Method. Filtering Cold | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Pb Foil Standard | | | | $PbSO_4$ Standard | | | |
| | A | B | C | D | A | B | C | D |
| Jig concentrates.... | 76.2 | 76.6 | 76.6 | — | 76.0 | 76.3 | — | 76.0 |
| Vanner concentrates | 51.0 | 51.4 | 51.3 | 51.2 | 50.8 | 51.2 | — | 50.8 |
| Crude carbonate.... | 30.0 | 30.2 | 30.2 | 30.2 | 30.0 | 30.1 | — | 29.9 |
| Crude sulphide...... | 17.2 | 17.5 | 17.2 | 17.1 | 17.2 | 17.4 | — | 16.9 |
| Zinc concentrates... | 7.5 | 7.6 | 7.5 | 7.5 | 7.5 | 7.6 | — | 7.4 |

| Ores | Ammonium-Molybdate Method Filtering Hot Pb Foil Standard | | | | The Dichromate Method | | | | The Gravimetric Method | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | A | B | C | D | A | B | C | D |
| Jig concentrates ... | 76.2 | 76.8 | 76.8 | 76.5 | 76.1 | 76.2 | 76.4 | 76.5 | — | — | 76.4 | — |
| Vanner concentrates.. | 51.1 | 51.4 | 51.4 | 51.0 | 50.5 | 50.7 | 51.2 | 50.3 | — | — | 51.1 | — |
| Crude carbonate .. | 30.1 | 30.2 | 30.2 | 30.1 | 29.8 | 30.1 | 30.1 | 29.9 | — | — | 30.0 | — |
| Crude sulphide ... | 17.4 | 17.1 | 17.2 | 17.1 | 17.0 | 17.1 | 16.9 | 17.1 | — | — | 17.2 | — |
| Zinc concentrates .. | 7.5 | 7.6 | 7.5 | 7.5 | 7.5 | 7.4 | 7.4 | 7.5 | — | — | 7.4 | — |

The table shows closely concordant results. When $PbSO_4$ is used as the standardizing agent, the results average 0.3 per cent lower in total lead than when metallic lead is used, due to the fact that lead sulphate is slightly soluble in the menstruum. When metallic lead is used this error is compensated, for the same solubility occurs in the case of both standard and ore. The results of hot filtering give slightly high results, probably due to the fact that the standard is high, due in turn to a slight solubility of lead sulphate in hot solutions.

The chromate method was not recommended by the committee because "it requires two filtrations and the use of two standard solutions, which greatly increases the amount of manipulation." (The chromate method tested is not that of Low, which is gaining favor in this country.)

The gravimetric method is suggested as being useful for purposes of checking the results of the molybdate method.

The molybdate method is recommended. Standard ammonium molybdate solution contains 8.8 g. of the C. P. salt dissolved in 1 liter distilled water. Tannic acid indicator is made by dissolving 1 g. tannin in 300 cc. distilled water, to which 5 cc. glacial acetic acid is added as a preservative. Ammonium acetate solution is made by mixing 2 liters each of ammonia and distilled water, adding 2 liters glacial acetic acid and making faintly alkaline.

The solution is standardized by either lead sulphate or metallic lead; if the latter is used, the precipitate is to be filtered cold. The calculation of the standard, and of the amount of ammonium molybdate necessary to affect the indicator, is made as follows: Make two titrations on different quantities of lead or lead sulphate; subtract the lower quantity from the higher, and the corresponding lower burette reading from the higher. Calculate the standard from the remainders, thus getting the true standard, exclusive of the indicator. The amount of solution necessary to affect the indicator is then found by dividing the standard found into either of the weights of lead taken, which will give the number of cc. of solution required at that standard. The number of cc. found first by calculation is subtracted from the number of cc. found by titration, and the difference will be the quantity required by the indicator. This amount is to be subtracted from each burette reading on an assay before multiplying by the standard. Thus.

| Lead taken | Burette reading, cc. |
|---|---|
| 0.3549 | 35.3 |
| 0.1575 | 15.7 |
| 0.1974 | 19.6 |

$0.1974 \div 19.6 = 0.010071$ g. of lead—the true standard then $0.3549 \div 0.010071 = 35.24$ cc.;
therefore $35.3 - 35.24 = 0.06$ cc., which is the quantity required to affect the indicator, and which should be subtracted from a burette reading before applying the standard.

In the presence of large amounts of lime the method is modified by precipitating the lead from its ammonium acetate solution with ammonium sulphide, filtering, dissolving in nitric acid, evaporating nearly to dryness, neutralizing with ammonia, adding 30 c.c. ammonium acetate and titrating.

When antimony is present, carry the assay to the lead sulphate stage as usual, then dilute with water and add Rochelle salt to dissolve the antimony. Filter, wash and treat the lead sulphate as usual.

When tungsten is present, decompose the ore *thoroughly* with HCl; then add HNO and evaporate to about 5 cc. Dilute with 80 cc. hot water, filter and wash with boiling water. Treat the filtrate with $H_2SO_4$ and proceed as usual.

---

**Fuel Oil.**—Circulars 140, 141, and 142 of Messrs. Tate, Jones & Co., Inc., of Pittsburgh, Pa., deal with fuel oil. Circulars 140 and 141 describe this firm's appliances for handling and burning fuel oil, circular 142 gives fuel oil data from actual experience. One big advantage of oil as a fuel in boiler work, whether marine or stationary, is the fact that with oil the boiler can be pushed way beyond its rating and an evaporation obtained that would be impossible with coal. "Recent tests made by the U. S. Navy Department show that the heat-absorptive power of boilers is very great and that boilers can be pushed with little drop in efficiency far above their normal rating. The evaporation per square foot of heating surface has been increased from 3 lbs. of water from and at 212° to 15 lbs. of water with a drop of efficiency of only 10%." Data are given on the use of fuel oil in furnace work—direct-fired, reverbatory, regenerative, and crucible furnaces, also kilns, etc.

# New York Meeting of the American Institute of Chemical Engineers

## Report of the Proceedings and Abstracts of Papers

The sixth annual meeting of the American Institute of Chemical Engineers was held in New York City from Wednesday, December 10, to Saturday, December 13, the headquarters being at the Chemists' Club, where all sessions were held. The attendance was particularly good.

At the business meeting held on the morning of Wednesday, Dec. 10, the result of the annual election of officers was announced as follows:

Professor M. C. Whitaker, of Columbia University, is the new president.

Dr. A. C. Langmuir was elected a vice-president; Dr. John C. Olsen, of the Polytechnic Institute of Brooklyn, N. Y., and Dr. F. W. Frerichs were reelected secretary and treasurer respectively; Mr. H. M. Kaufmann was elected auditor and Messrs. Henry Howard, John C. Hebden, and I. P. Lihme directors of the Institute.

M. C. WHITAKER, PRESIDENT AMERICAN INSTITUTE OF CHEMICAL ENGINEERS

### Sanitation Control of the City of New York

In the professional session which followed, the first paper was presented by Dr. Ernst F. Lederle, Commissioner of Health of the City of New York, who extended the city's welcome to the Institute in behalf of the Mayor, and then discussed in a very interesting manner the sanitary control of the City of New York by the Department of Health, showing by lantern slides many views of the "yearly clean-up" which was attempted for the first time in 1913 in New York City and the methods of disposing of the immense quantities of various refuse collected from the streets and houses. The lecture was profusely illustrated by lantern slides.

### Recent Developments in Commercial Explosives

A paper by Mr. E. A. Le Sueur gave a sketch of the recent trend in explosives development. The most striking feature among the changes occurring in the field is the almost omnipresence of nitrate of ammonia. Although a salt of a hypothetical metal it breaks down into a gaseous mixture containing a surplus of free oxygen and no solid residue whatever and, insofar, is therefore peculiarly suited to employment in explosives. Unfortunately it is very hygroscopic and of deplorably low specific gravity so that but a comparatively small weight can be packed into a given cavity. On the other hand, its adaptability, within the above limitations, is remarkably wide, and it is associated with almost every ingredient known to explosives manufacture, and especially with nitro-glycerin. So wide is the present market for this material for use in explosives that practically the entire output of the gigantic Norwegian atmospheric nitrate works is now delivered in the form of nitrate of ammonia, and further important developments in the cheap manufacture of this compound are to be looked for in the very near future.

Perchlorates, and especially perchlorate of ammonia, have numerous advocates among the inventors, but so far do not appear to have entered the market to any very great extent. Perchlorate of ammonia is obviously, from its chemical formula ($NH_4ClO_4$) well adapted to act as an explosive itself and at the same time provide three atoms of excess oxygen to combine with additional material. Aside from any other considerations, it possesses the serious defect of liberating considerable hydrochloric acid or a mixture of the same with chlorine. The use of certain powdered metals in the mixture serves very largely to eliminate both of the above gases.

A most profound impression has been made in the explosives trade of late years by the nitro derivatives of toluol, and especially by the various commercial mixtures of di- and tri-nitrotoluol now on the market. The cheddites (practically mixtures of the higher nitrotoluols with chlorate of soda and a vegetable oil, preferably castor oil) have achieved considerable well-earned popularity, and the flood of current patent applications for explosives containing tri-nitro-toluol reminds one of nothing so much as of that which occurred some ten years ago for acetylene generators.

Bearing in mind that tri-nitro-toluol possesses certain of the properties, so far as explosive effects go, of nitro-glycerine itself; that it withstands water and is not affected by cold, and that it can be handled with absolute safety until blended with other materials that may increase its sensitiveness, it is not difficult to understand the enthusiasm with which it has been received by amateurs as well as by others in the explosives field. Aside from any admixture with other materials it forms, in the refined condition, an explosive of quite ideal properties for use in shells, torpedoes, mines and the like. In spite of its fierce and terrific disruptive energy and of an enormous speed of detonation, it is a safer material to handle, transport and store than, for instance, ordinary calcium carbide.

And, notwithstanding its inert behavior, it can be depended on absolutely to explode completely when exposed, in a suitable physical condition, to detonation from an adequate primer. Several European governments are now making extensive use of this intensely interesting compound. Owing to the fact that its constitution ($C_7H_5N_3O_6$) presents too little oxygen to combine completely with the carbon contents even to the monoxide form the result of explosion is the formation of a cloud of carbon particles which will presumably have its advantages in warfare both through marking the position of a shell at the instant of explosion and by obscuring the enemy's vision.

The liquid nitro-toluols are also finding an important use in connection with nitro-glycerine. They greatly lower the freezing point of the latter, contribute their quota to the explosive effect, and render the resulting explosive much safer than before.

In addition to the above compounds and many others (including the nitro-napthalenes, benzenes and xylols) the old stand-by, chlorate of potash, holds its own as a prime constituent of modern disruptive powders. It may be worth while to glance for a moment at the extraordinary thermo-chemistry of the chlorates and perchlorates, the same having a vital bearing on the matters of energy developed, sensitiveness and stability of certain explosive mixtures containing them.

Chlorate of potash disengages heat energy to the extent of 93,800 calories per kilogram molecule on formation from its elements, but potassium chloride disengages 105,700 calories, or 11,900 *more* than the chlorate. The addition of three atoms of oxygen to the chloride is accompanied by the absorption of energy to this latter extent, the formation reaction being endothermic. Perchlorate contains one-third as much oxygen again as chlorate, but instead of the addition being accompanied by a further absorption of heat, there is actually a disengagement of energy, accompanying the entry of this lone atom, of far more (19,900 calories altogether) than the entire amount absorbed when the first three atoms were added.

Chlorate stands ready to fall to pieces on scant provocation and, in doing so, give up not only three atoms of active oxygen to any combustible in the neighborhood, but 11,900 calories per kilogram molecule as well. Perchlorate, on the other hand, in spite of its higher degree of oxygenation, requires more energy to drag it to pieces than does the chloride itself, and, in consequence, forms a less sensitive and less energetic constituent for an explosive than the less oxygenated chlorate.

In the light of the above, and especially in view of the fact that the besetting trouble with most modern chlorate explosives is lack rather than excess of sensitiveness, it will be seen that plain chlorate presents certain large advantages over perchlorate for many explosives. This will help to explain the fact that, although modern electrochemical methods enable the ready production of perchlorates, the latter have not, so far, become serious competitors in the field of commercial explosives.

Mr. Le Sueur then dealt at some length with a chlorate explosive developed by himself and which has come into widespread commercial use.

In manufacturing this powder five parts of paraffine wax are melted and four of ground sulphur and twenty-two of nitrate of soda stirred into it; the mixture is allowed to cool and is then grained. The resulting material is called "mineral base." In spite of containing an oxidizing agent and combustibles it is completely inexplosive technically. It is finished to explosive by dusting 8 parts (to the above 31 of base) of powdered chlorate of potash over the grains.

The final material possesses a number of interesting features. Due to an extremely low speed of detonation it develops its power in a way peculiarly available for the requirements of many large applications such as heavy rock work, clearing land of stumps and the like; and, owing to the said low speed of detonation, its high effectiveness for these purposes, even compared with explosives possessing decidedly greater energy content, is quite surprising. Its insensitiveness is such that it withstands the impact of a steel tipped service rifle bullet fired from the regular service rifle with a standard charge behind it without response of any kind; although, due to its property of going out after being set fire to when the flame causing ignition is removed, it is possible that incipient ignition occurs during the passage of the bullet.

If packed hard it is impossible to explode it by any means whatever. On the other hand, loaded loose, it is an absolutely sure fire with a No. 6 detonator even when unconfined, and, for work in earth, as in removing stumps, it is necessary to bear in mind that confinement may be negligible. When well confined in large shots in solid rock, and especially if detonated with a stick of dynamite, it will withstand any reasonable amount of packing and still give a sure fire.

From its composition it will be obvious that it is non-freezing, and, indeed, owing to the paraffine wax incorporated in it becoming harder with increasing cold, it loses its porosity through being pressed into holes less readily cold than otherwise. With regard to stability, it withstands the international stability test (75 deg. C. for 48 hours) with indifference, whether with moisture added or not, and some millions of pounds have been used during the past seven years, and in some cases excesses over requirements have been stored by contractors in badly constructed magazines, occasionally for years, and there has never been any sign of heating or decomposition, incipient or otherwise.

The very low chlorate content and the fact that all the other materials are used in their crude commercial condition, together with the extremely simple process of manufacture, render the cost of this powder exceptionally low. It is known under the name of R. R. Virite.

With reference to the property which this explosive, in common with very many others, has of being more difficult to explode as its porosity diminishes, Mr. Le Sueur points out a certain important corollary which exists in a case where the insensitiveness when closely packed reaches the point it does in a case such as the one under discussion. If compressed forcibly to a specific gravity of about 1.45 it has been found impossible to explode by any amount of detonation, no matter what the degree of confinement. This in spite of the fact that a certain small amount of local combustion occurs where the material is in direct contact with the detonator.

The superficially paradoxical situation confronts us that the only condition in which the material can be exploded by hammering between hard surfaces is one in which it becomes insensitive to detonation from another explosive. By this is meant that, in order to cause explosion of the powder by hammering, it has to be packed to a maximum density before the pinching between hard surfaces necessary to cause explosion occurs. Of course, what happens when the material is hammered on an anvil is that any excess over what can be pinched down to the thickness of thin paper between hammer and anvil is forced aside and only the trifling amount of powder actually so pinched goes off, and it has hitherto been found impossible by any degree of practicable impact to communicate explosion from the quantity so pinched to the rest of the mass of powder. The importance of this peculiarity in securing freedom from accidents in any case other than where the powder is exposed to detonation from another explosive is obvious.

If we consider what is the fundamental difference between the blow of a hammer and that of a detonator we see at once why a mass of the explosive which refuses to transmit detonation however powerful (within the enormous upper limit experimented with) when in a dense (non-porous) condition, why such material may be readily exploded when in a porous condition by a detonator although a blow from a hammer can only have a local effect. The point is that, in the former case, the blow is struck so quickly that the explosive is hammered between the products of explosion of the detonator and, if this expression may be used, its own inertia, without having time for its porosity to be interfered with. The passage of a bullet exposes it to the same kind of a blow against its own inertia, but the swiftest bullet is so far inferior in speed to the velocity of the products of explosion of a detonator that it falls short, in the case of a powder of the class under discussion, of producing an explosion. There is also, of course, the essentially important feature, in the case of explosion by a detonator, of exposure to vastly greater heat than from the friction of a bullet or impact of a hammer.

The well-compressed material behaves, as previously stated, in a completely inert fashion to attempts to detonate it, but mere crumbling restores it to the explosible condition. It would seem as though a technical division on the lines of classification according to safety might well be adopted to embrace explosives that require outside detonation from another explosive in order to set them off.

Mr. Le Sueur finally discussed liquid oxygen as a constituent of explosives. Modern methods exist for producing this element in a state of high technical purity in the liquid form at a cost extremely low compared with its cost in the combined form in any of the chemicals employed in the explosives trade. So that completely smokeless and fumeless mixtures equal to 75 per cent dynamite can be made at a cost of about 2 cents per pound. As regards safety, explosives containing liquid oxygen stand in a class by themselves in one particular, *i. e.*, in the fact that, should a shot be missed for any reason, the charge presently becomes inexplosive through volatilization.

Of course, this is merely the merit which accompanies the greatest defect of these explosives. They must be used within a few minutes of being compounded. Nevertheless, this is by no means the absolutely prohibitive feature that might be expected, owing to two considerations, one of the numerous gigantic individual blasts that are necessary on certain heavy construction works (the time required for the charge to evaporate being comparatively long in such cases) and the other the fact that the addition of the liquid oxygen to the combustible portion of the charge may be made the last thing before firing. Mr. Le Sueur is rather firmly of the opinion that in the heaviest construction works of the future, especially where the so-called "coyote" shooting can be employed, liquid oxygen will play an important part.

In conclusion Mr. Le Sueur referred briefly to the hopes of the nitro-glycerine manufacturers that in synthetically prepared glycol may be found the solution of their bondage to the fluctuation of the corn and cotton seed crops. The production of glycerine depends considerably on the abundance or otherwise of pork and of cotton seed oil and the former depends largely on the corn supply. The stearine candle industry, another feeder to the high explosives maker, is not in a healthy condition, and altogether the situation of the dynamite manufacturers is not so completely free from anxiety in the matter of their glycerine supply as they might wish.

**Dr. W. M. Grosvenor** then presented briefly his suggestions on a "practical road to a standard catalog" of products of manufacturers for the chemical industries.

### Presidential Address

In an evening session on Wednesday, held again at the Chemists' Club, the retiring president of the Institute, **Dr. T. B. Wagner**, presented an admirable address on the effect of legislation upon chemical industries.

This address is printed in full elsewhere in this issue.

### The Clam-Shell Filter Press

A paper on the Sweetland clam-shell filter press was presented by **Mr. E. J. Sweetland** and illustrated by numerous lantern slides and demonstrations of a working model. We herewith give Mr. Sweetland's paper slightly abstracted.

That there is great room for improvement in the methods of filtration commonly employed cannot be doubted. The plate and frame filter press ordinarily used comprises anywhere from forty to one hundred filter chambers each of which must be cleaned individually by hand every time the filter is filled.

It was to eliminate the excessive amount of hand labor in cleaning filter presses that the filter under discussion was primarily designed, but as the construction was developed many incidental advantages of importance developed with it.

The single advantage in plate and frame filter presses that has kept them in favor is the fact that their peculiar construction affords a very large filter area in a comparatively small space. Filtration cannot be forced beyond a certain reasonable limit, when this limit is reached it is necessary to increase filter area to increase capacity. To endeavor to increase capacity by increasing pressure instead of filter area is futile, for excessive pressure merely presses the cake to a compact, almost impervious layer, and the object is defeated at once.

With this in view, the modern filter must not depart from a construction that permits of ample filter surface. Other things being equal, the capacity, and consequently the value, of a filter is proportional to the filter area.

The sluicing type of filter press is one example of a filter press construction that eliminates hand labor in cleaning. In this type the cake is disintegrated by a stream of water forced into each chamber. The cake thus liquefied flows to the waste reservoir, or dump. The usefulness of this method is limited for obvious reasons, principal of which is the need of recovering the cake as dry as possible in most processes.

The uses of filter presses are so varied that great flexibility is required. To be a commercial success the modern filter press must lend itself to the various requirements which may come up, and the construction made adjustable as far as possible.

#### CONSTRUCTION

The Sweetland filter has become known as the "clam-shell" type, due to the shell being in two parts hinged together to open and close somewhat after the manner of the clam shell bucket used on steam shovels.

The filter body comprises two semi-cylindrical members hinged together, one member being provided with an inserted gasket which seals the joint between the two to form a water-tight cylinder when closed. Fig. 1 shows an end and side elevation of the filter in closed position.

A plurality of openings is provided along the top to receive the stem or outlet nipple of the filter leaves. These outlets are spaced quite close together, so that the leaves may be closely spaced if desired, as is the case when thin cakes are to be formed; but the leaf spacing may be increased to any degree by taking out part of the leaves and stopping off the intermediate outlets.

Variable spacing is quite essential, for it is not always possible to ascertain in advance exactly what spacing will be best suited to the material; and further, there is always the possibility of the process being modified to change the filtering properties of the material and make a change in leaf spacing desirable.

The filter leaves are usually made of wire screen, well crimped to provide ample drainage. The screen is bound at the edges to stiffen the construction and protect the cloth. An outlet nipple with a side opening furnishes an exit for the filtrate and means of holding the leaf in the filter body. The filter cloth covers the entire metal construction of the leaf except the outlet nipple, and is held on either with metal clips or by being stitched around the edges.

The leaves are held in place in the filter by a cap nut which engages the top of the nipple and draws the shoulder of the leaf tightly against the rubber washer which fits in a recess inside the filter body. The side outlet of the nipple aligns with the filtrate delivery fittings on the outside of the press.

Fig. 2, which is a cross section of the filter body clearly shows how the filter leaves are held in place by the nipple at the top. Each leaf has separate outlet fittings comprising shutoff cock, glass delivery tube, etc. These fittings allow the operative to see the filtrate from each individual leaf as it flows through the glass, and any leaf that might become injured or require renewal of cloth is indicated at once by a turbid filtrate in the glass. In this event the shut-off cock governing the defective leaf is closed until the filter is opened and the leaf replaced. To remove a leaf only the cap nut has to be removed—the outlet fittings are not disturbed.

In the earlier designs of this filter the two halves of the shell were held in closed position by hand operated swing bolts. These were fairly quick and convenient to operate, but still left room for improvement. It was desired to modify the construction to an extent that would reduce the time to unlock and open the filter from a few minutes to a few seconds, if possible. This was accomplished by a very simple change in the construction. The hinges, which formerly took no strain while the filter was in locked position, were increased in strength and number and made to take the strain formerly taken by the swing bolts on the back of the filter body. To eliminate any possibility of breakage, the hinges are made of steel, which can be fully depended upon for strength.

What seemed the great problem in working out this improvement was the need of accurate hinge adjustment to take up wear in the gasket. This problem like many mechanical problems proved to be simpler than was anticipated, for it was solved by simply making the hinge pins into one continuous shaft reaching from end to end of the press, and turning the bearing which received all of the hinges on the upper member eccentric to the normal axis of the shaft. This construction not only affords adjustment, but makes adjustment of all hinges simultaneous by simply turning the hinge shaft slightly when adjustment is necessary to draw the upper and lower halves of the shell closer together as the gasket gradually flattens out from continued use. The shaft is held from turning by set screws, which are loosened when adjustment is made.

An eccentric shaft with swing bolts rests in babbitted bearings along the front of the upper half. Each bolt has an adjusting nut and lock nut for initial adjustment and for taking up wear. The swing bolts are tightened or loosened simultaneously, due to the eccentricity of the shaft, when the latter is turned through an arc of 180 degrees, and means is provided of swinging the bolts clear of the lugs on the lower half just at the point when they have loosened sufficiently to disengage themselves.

This arrangement makes it possible to open or close a filter press of moderate size in a few seconds. The lower half of the shell is poised with counterweights to facilitate opening and closing. A sectional view, showing hinges, eccentric shaft, etc., is shown in Fig. 26.

In large machines an eccentric shaft is used on both front and back, and a hydraulic cylinder operates the two simultaneously by means of a cross head and connecting rods. The lower member in this case is swung open and shut by a hydraulic cylinder at either end which is so arranged that the shell is opened so wide as to invert it and thus clean itself of any cake that might have fallen before it was fully opened.

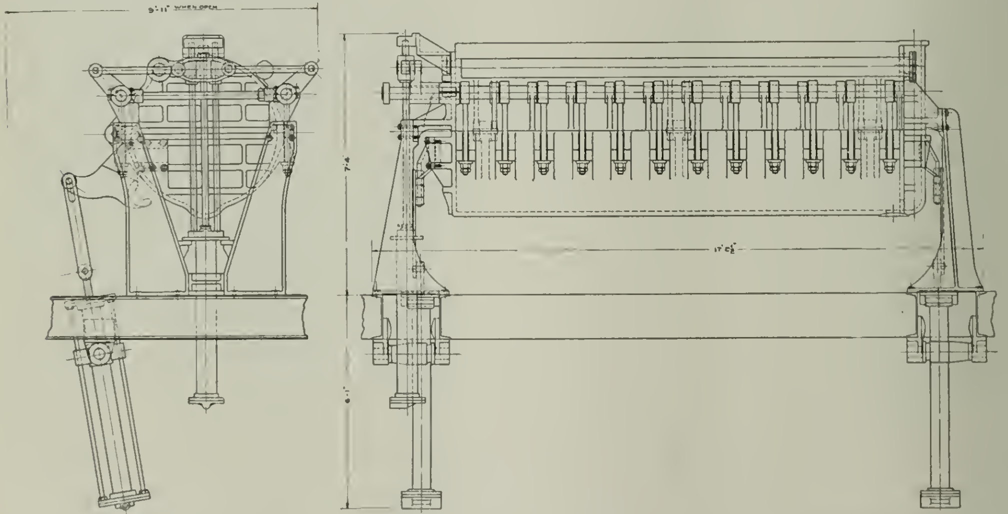


FIG. 1.—END ELEVATION AND SIDE ELEVATION OF CLAM-SHELL FILTER PRESS IN CLOSED POSITION

### OPERATION

In operating the filter the liquid to be filtered is forced into the filter body under pressure, expelling the air and entirely submerging the filter leaves. The liquid filters through the cloth and deposits the suspended solids on the outside of the leaves, forming the "cakes." Filtration continues until the cakes on adjacent leaves are separated only by a narrow space which may vary in width from 1/8 inch upward. When the cakes are formed to the proper thickness the wash water valve is opened and sludge valve closed simultaneously.

The wash water enters the space between the cakes forcing the small quantity of unfiltered sludge to deposit its solid component upon the cake surface. The space between adjacent cakes is now occupied by water, which being under pressure, percolates through the cakes, driving the strong liquor ahead and effectively displacing it until the cakes are washed to the desired degree, as indicated by frequent tests of the effluent.

Mr. Sweetland enlarged upon the subject of washing the cakes, for therein lies a great difference between his and other leaf filters. It should be noted that there are no chambers or containers to be packed solidly full of cake. The spaces between the leaves are not packed solidly full, but a cake is deposited on the surface of each leaf and these cakes are allowed to build up until only a narrow space remains between them, and in this space lies the secret of successful automatic discharging of the filter and efficient washing.

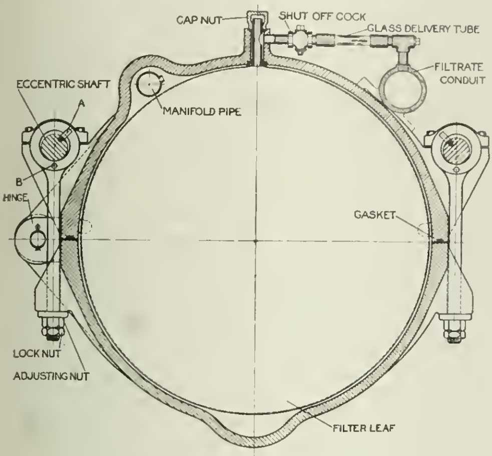


FIG. 2.—CROSS SECTION OF FILTER BODY

The cakes have been formed under equal conditions, the sludge being evenly distributed and the pressure equal throughout the filter chamber; therefore the cakes must be of even thickness and density, and must wash evenly. That this actually occurs has often been demonstrated by testing samples of the washed cake from various parts of the press.

All filters of the leaf type wash by "direct contact" methods; that is, the wash water is in direct contact with the cake; but the methods of washing that have heretofore been practiced with leaf filters, whether vacuum or pressure, are indeed anything but direct.

The usual method of forming and washing the cakes on filter leaves is as follows, assuming that the cake has to be washed first with weak liquor and then with water: Fill filter tank; deposit cake on leaves; withdraw excess solution; fill filter tank with weak solution; wash cakes with weak solution; withdraw excess weak solution; fill filter tank with water; wash with water; withdraw excess water; discharge cakes from leaves.

Here are ten distinct operations, which are still further complicated by the fact that the cakes will not cling to the leaves unassisted, but must be held on with either compressed air or vacuum during the time each quantity of excess is withdrawn. Mr. Sweetland did not dispute that the cakes can be washed well by this method, but raised the point that it is an extremely round-about method of accomplishing a simple object. Most of the power consumed is not devoted to filtration, but to transferring solutions, much of the time is not devoted to filtering, but to waiting for transfers to be made, and the operative is kept busy manipulating valves.

The delay in filtering necessitated by the many transfers materially cuts down the duty of the filter, and the process becomes a complicated one, requiring many tanks and much accessory apparatus to take care of excess solutions.

Nor is this all. The transfers of excess solutions referred to introduce other complications. The cakes must be supported upon the leaves at all times by pressure. Air pressure (whether produced by suction or otherwise) must be used during the transfers. If too much pressure is used, the cake will be cracked (due to the shrinkage of partial drying) and the wash water will "short circuit," that is, pass through the channels formed by cracking. If too little pressure is used, all or part of the cakes may fall from the leaves, which would preclude the possibility of efficient washing. Lastly, if the cakes are of a fine slimy character, the partial drying during the transfer packs the particles of slime, and makes it less pervious than ever to the passage of wash water.

The origin of the many complications cited above is traced directly to void or "dead" space in the filter tank or chamber which contains the filter leaves. If there were no dead space there would be no excess solutions, and consequently none of the complications which attend them.

The "clam-shell" construction of filter body has no void space. It contains nothing but the filter leaves and manifold pipe. When the filter leaves are loaded with cake the entire filter chamber is full except the feed channel for distribution along the bottom, and the narrow space between the cakes for the entrance of wash water. There is, therefore, no excess solution to handle. Filtration is continuous from the time cake forming is commenced until washing is finished, and the process of filtering and washing is reduced to the simplest possible terms.

When washing is finished the cakes are partially dried with compressed air, the lower half of the filter body is swung open and the cakes are dumped into a car or conveyor underneath. To assist the cakes to dislodge from the leaves, the current is reversed by turning steam or compressed air inside of the leaves, which not only causes the cakes to drop off, but benefits the cloth by keeping the pores open.

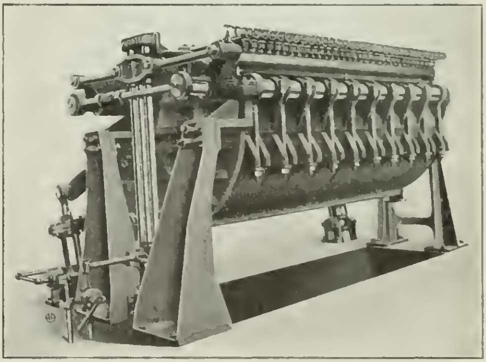


FIG. 3—HYDRAULICALLY OPERATED SWEETLAND SELF-DUMPING FILTER CLOSED

For the benefit of those who insist that better washing can be obtained by draining the filter body before introducing wash solutions or water, Mr. Sweetland pointed out that the filter construction here described offers every facility for carrying out this method, if desired; but, after installing many of them, large and small, under widely varying conditions, and seeing trials made both ways, he strongly advocates the direct method without withdrawing solutions.

If the material is very slow-filtering and the space between the cakes wide, then it is better to introduce the wash water through the manifold pipe and let the water entering the top fill the chamber by downward displacement, forcing the excess solution out of the drain valve at the bottom. The water being lighter than the sludge, it does not mix with it, but floats on top during displacement. In this case filtration is continuous, pressure is maintained in the chamber, no time is lost, and the cakes are constantly submerged.

Mr. Sweetland then discussed why the body of this filter was designed cylindrical instead of square. Obviously the principle could be carried out in a filter body of square or rectangular section. The reasons for cylindrical construction are: The cylindrical construction affords great strength, whereas any shape with straight sides would require so much reinforcement to give it the necessary strength as to make it cumbersome and awkward.

In the cylindrical construction the leaves are exposed to view by simply swinging the body open.

A circular leaf is conveniently supported from one point and is very strong and light.

If the chamber were square the leaves would be inaccessible, or else would have to be lifted out with the cover to discharge, and this would involve mechanical difficulties.

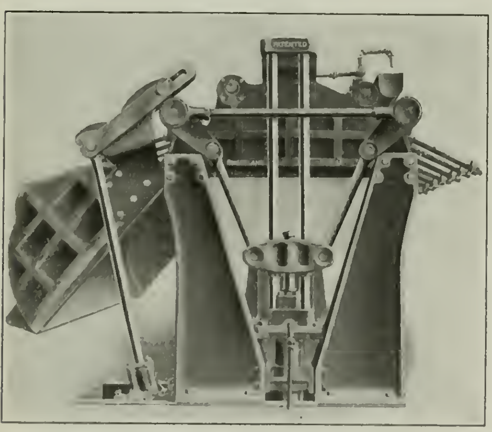


FIG. 4.—END VIEW OF FILTER OPEN

The circular form of leaf does not involve as much waste in filter cloth as might be imagined. There is to be sure a slight waste of cloth cut from the corners, but most of this has an important use in reinforcing the cloth at the edges of the leaf. On the other hand, a large percentage of the cloth used in plate and frame presses is not used for filtering, but to form a joint between the frames. If we figure it out in any case, we find that the percentage of cloth purchased that is utilized as filter medium is about the same in either case. In fact the cost of cloth per unit of work done is much less in the case of the leaf construction, because the capacity per square foot is greater, and the cloth is not injured by being squeezed between the frames.

As to filtering mixtures containing coarse particles, these offer difficulty in any type of filter, due to the coarse particles settling to the bottom, making the bottom of the cakes more porous than the top and resulting in uneven washing. The remedy for the trouble is to keep the contents of the filter chamber in a state of agitation. To accomplish this the feed pump is provided large enough to supply the necessary pressure for filtration with additional capacity enough to permit a restricted overflow to run from the manifold pipe back to the supply tank during filtration.

### FILTER AIDS IN FILTERING MATERIALS CONTAINING A GUMMY RESIDUE

New light is being thrown on the subject of filtration with almost every new installation, and problems are being successfully solved that appeared at the start to be impossible of solution. To cite an instance: A sample of a heavy viscous liquid was submitted for test. It contained a gummy residue that blocked the filter cloth from the start, and the rate of flow of filtrate per square foot of cloth was but a few cubic centimeters per hour, and the cloth became so coated as to defy cleaning by any practical method.

As the solution only was required, and the residue was worthless, there seemed to be no objection to adding some inert granular substance to the liquid as an aid to filtration. A series of experiments was undertaken, adding various "filter aids" to the fluid, and the outcome of this work was that an average rate of filtration of three gallons per square foot of cloth per hour was obtained and the gummy residual matter was sufficiently broken up to permit the filter cloth to be readily cleaned by reversal of current. Upon completion of the tests, a filter was installed in the plant and has fully demonstrated the practicability of the method on a working scale.

It was found that any one of several substances could be used as an aid to filtration, among which are fine sand, fuller's earth, kieselguhr, sulphate or carbonate of lime, sawdust, wood pulp, etc.

It is not argued that such methods are applicable to all cases, but there are unquestionably many problems that will find solution in similar schemes, which make possible rates of filtration such as are usually obtainable only in sand filters, with the added advantage that the leaf filter offers an enormous filter area in a small space, combined with extraordinary ease of cleaning.

Another method of filtering materials containing a gummy residue that tends to choke the cloth is that of depositing a protecting layer on the cloth before commencing filtration. For instance, we may first fill the filter body with a very thin slurry of carbonate of lime and filter this mixture for a few seconds until a film of lime, say 1/32″ in thickness has been deposited. This coats the cloth as completely and evenly as a deposit could possibly be made. The lime slurry is then drained off and filtration commenced. The coating of lime forms a complete film between the cloth and gummy residue, so the latter never even touches the cloth. When ready to clean the cloth the reversal of current is effective, because the coating of lime breaks away readily.

It is frequently asked how we can tell when cakes of sufficient thickness have been formed, especially when the material filters and builds up the cake rapidly. This is not as difficult as would be imagined. The usual way is to work at a given pressure, say forty pounds per square inch, and pump for a certain number of minutes, determined by practice to form the required cake. Another way is to pump a certain number of inches from the supply tank for each charge. As in all processes, the operative soon becomes expert and can judge from the general conduct of the filter when the charge is sufficient.

The usual skepticism which attends the introduction of any new machine was encountered at first, but so many installations are now in successful use as to establish fully the usefulness of the methods described. A noteworthy point is the fact that many of the filters of the type in use are of much larger size and capacity than it is found practicable to build filter presses. Many have been built with a capacity of 133 cubic feet of cake per charge and several others ranging from 80 to 120 cubic feet per charge. One especially large one was built which dumps over 25 tons of cake per charge.

That this apparatus is now far beyond the experimental stages is demonstrated by the fact that a large beet sugar factory in California installed three large hydraulically-operated machines for the 1913 campaign. They were installed almost at the last minute before the campaign started and were at once placed in service at full capacity, and no difficulty was encountered, in spite of the fact that none of the employees who operated the machines had ever seen one before. The time required to open, clean and close one of these filters is about five minutes, which minimizes labor to such an extent that one operative can take care of several large machines, even though each machine has to be cleaned hourly.

### Electrolysis of Chloride Solutions with a Mercury Cathode

In a brief paper by Mr. E. A. Le Sueur reference was made to the author's well-known pioneer work on the electrolytic production of caustic soda and chlorine started in 1888. While in this work Mr. Le Sueur developed the diaphragm process, his first experiments in 1888 were made with a mercury cathode.

The point emphasized by the author is that with a view to getting the sodium the worst possible place is to deposit it on top of a layer of mercury exposed to contact with the solution. The point is that, although sodium dissolves in mercury, the initially formed amalgam is of very low specific gravity compared with mercury itself and naturally tends to stay on top of the latter. The alternative occurred to Mr. Le Sueur to use the under side of the mercury as the cathode, the upper side being completely exterior to the electrolyzer as such, with the idea that the sodium, as fast as it was delivered to the under side, would bob up to the upper side and be thereby removed from relation with the electrolyzer and its contents.

This he proceeded to do, using a horizontal square frame of paraffined pine wood, a supporting sheet of a special cotton fabric carried by the under side of said frame, and additional support supplied to the fabric by a paraffined wood grating. Mercury was placed on the fabric to a depth just sufficient to cover it completely and a current supplied from a primary battery of three large bichromate cells between a carbon anode and the under side of the mercury, saturated salt brine being the electrolyte. As far as it went this experiment was successful, and the author is convinced that this general principle would work up to the best possible type of mercury cathode electrolyzer.

"In the light of the principle so clearly grasped in connection with the above quarter century old work, it is curious to note, in Wilderman's address before the International Congress last fall, the repeated remarks on the disadvantages all processes previous to his have labored under of putting the light sodium on the top layer of mercury and leaving it there."

### New Filter Press

The first paper of the Friday morning session was presented by Dr. **Alfred Burger** on a new filter press which appears to have some important advantages over the old chamber press. It is really a novel and very ingenious system of piping in connection with the filter press. The principle of washing is the same as in the Sweetland press, but the method is different and Dr. Burger's system can be attached to any chamber press. The following figures were given, the figures in row No. I referring to an old chamber press, those in row No. II to the Burger press, and those in row No. III to a filter press of the leaf type.

| | Washing efficiency | Final $H_2O$ left | Pound of dry [illegible] per filter per sq ft per hour |
|---|---|---|---|
| I. | 20% | 60% | [illegible] |
| II. | 60% | 28% | 3 |
| III. | [illegible]% | 56% | 3.5 |

### Ozone

Dr. **A. Vosmaer** then presented a very interesting lecture illustrated by lantern slides on ozone, its manufacture and use. The paper consisted of three parts, dealing respectively with the methods of manufacture, the properties of ozone, and its uses, especially for sterilization of water, for deodorization of air, and the applications of ozone in the chemical industries.

Since Dr. Vosmaer is writing a special elaborate series of articles for this journal, discussing the subject in great detail, it must suffice here to refer the reader to these articles. The first two articles of this series appeared on pages 623 and 705 of Vol. XI, 1913, and a third article will be found elsewhere in the present issue.

In the discussion Dr. Franklin spoke vigorously on the stir caused by the recent agitation of medical circles against ozone. Their experiments as to the fact that ozone does not kill bacteria in air were perfectly right, but did not refute in the least anything that had been claimed by intelligent and reliable advocates of the treatment of air by ozone.

### Wood Turpentine Industry

A paper on the status of the wood turpentine industry by **E. H. French** and **James R. Withrow** was then presented by Dr. Withrow.

This paper outlined the present status in this industry and compared the same with that of gum turpentine. Emphasis was laid upon reasons for past failures in the business and upon the fact of its economic necessity for the utilization of cut-over timber lands.

The various processes for producing wood turpentine which have been in extended use, namely, the steam, solvent, alkali, bath, and distillation processes were discussed, giving general data derived from commercial operations as to yields, value of products, cost of operation and construction. The advantages and future possibilities, together with the disadvantages of each process, were discussed, but no particular process was recommended to the exclusion of others. The conditions under which only each may operate with profit were indicated.

As many of these figures in this paper contain heretofore unpublished information the paper will be published in full in our February issue.

The paper was discussed at some length by Dr. Wagner and Mr. Chute.

### Symposium on Welfare and Safety Work in the American Chemical Industries

In the evening of Friday the members of the Institute were the guests of the New York Sections of the American Chemical Society, the American Electrochemical Society, and the Society of Chemical Industry, the program being a symposium on welfare and safety work in American chemical industries.

Miss **Florence Hughes**, member of the general staff for sociological work of the New Jersey Zinc Company, gave a general outline of organization and development of neighborhood work at Palmerton, Pa., of the welfare work in progress at Austinville, Va., and De Pue, Ill., and emphasized the consistent policy as applied to safety and hygiene in care of workmen. Several conclusive statements were made as to relation between settlement work and the industrial and social problems.

Mr. **Howard Lyon**, of the experimental department of the Welsbach Company, discussed in his paper safe conditions of labor, fire protection, means for promoting the health of employees and treating the injured, the establishment of an employees' relief association, and provision for æsthetic and cultural betterment.

Mr. **Charles P. Tolman**, chairman of the Manufacturing Committee of the National Lead Company, dealt with sanitary improvements in the manufacture of white lead, both in the corroding yard and the mill, welfare equipment and welfare work, safety devices for the prevention of physical injury, and emphasized the human element in work of this kind.

Dr. **Francis D. Patterson**, director of the Department of Sanitation and Accident Prevention of Harrison Bros. & Co., Inc., spoke of the sanitary measures, devices and improvements, and the means for the prevention of accidents, adopted by this company.

### Excursions

A very full program of excursions was provided which included a visit to the Barber Asphalt and Paving Company of Maurer, N. J., a whole-day excursion on Thursday to the plant of the Sanitary Utilization Company at Barren Island, with inspection of the Willard Park Hospital group of laboratories of the Department of Health of the City of New York, and excursions on Friday afternoon to the experimental electro-plating plant of Hanson & Van Winkle Co. at Newark, N. J., and the Atha Works of the Crucible Steel Company of America, at Harrison, N. J. On Saturday morning the chemical engineering laboratories at Columbia University were inspected.

The International Exposition of Safety and Sanitation, held under the auspices of the American Museum of Safety at the new Grand Central Palace, also attracted many members of the Institute.

A well attended and greatly enjoyable subscription dinner was held on the evening of Friday at the Chemists' Club, when the Institute medal was presented to Dr. Frerichs.

The place of the next meeting has not yet been determined, but it will probably be either Buffalo or Troy, N. Y.

## Analyses of Coals in the United States

The report just issued by the United States Bureau of Mines as Bulletin 22, entitled "Analyses of coals in the United States, with descriptions of mine and field samples collected between July 1, 1904, and June 30, 1910," contains the analyses of 5000 samples of coal taken from 1500 coal mines and prospects situated in the various coal fields of the United States. Not only all of the important fields are represented, but practically all of the more important mining districts.

The purpose of the bureau in compiling and publishing this information is to present reliable information regarding the chemical composition and heating value of the coals. The samples of coals were collected by experienced men according to a definite and uniform system, and were analyzed under carefully controlled conditions, so that there might be no question as to the relative merits of the different coals so far as this can be determined by chemical analyses and determination of heating values.

An increasing proportion of the coal consumed in the power stations and the larger manufacturing plants of the country is now being purchased under specifications based on chemical analyses and calorimetric determinations of heat units. In the purchase of fuels many matters that have been left to chance are now carefully investigated.

It is the aim of mechanical engineers to construct furnaces and to arrange the heat absorbing surface in a furnace with reference to the peculiar character of the fuel which is to be burned. Noting the composition of the fuel and constructing the furnace with reference to it, he can assure efficient and smokeless combustion. Moreover, in any particular market, the choice of coal generally is limited by its quality and by freight rates to one or two fields in which the character of the coal bed is comparatively uniform.

Having on hand a representative analysis of the coal from a given bed in any particular district, the engineer can determine whether the coal he receives comes from the bed and the district stated, and whether it is being prepared for market as carefully as it should be.

Wide variations in the composition and heating value of the coals from different districts and from different beds make analyses that are comparable, because of the care taken in sampling and analyzing the coal, almost indispensable to engineers having to install boiler or gas-producer plants in different cities, and also to railroads and steamboat companies, and to the engineers and purchasing agents of the various departments of the United States Government.

The report just issued by the Bureau of Mines is in two parts, one giving the methods used in collecting and analyzing the samples, and the results of the analyses, and the other giving the exact location from which each sample of coal was taken, together with a description of the characteristic features of the coal bed at the point of sampling, the nominal capacity of the mine, and such notes on the preparation of the coal as might be useful to consumers.

The data contained in these two volumes is not equalled in scope and detail and in value for comparative purposes by the figures that have been published by any other coal-producing country in the world. The governments of some of these countries have published analyses of coals from different mines and from different districts, but, with few exceptions, the samples of coal were not collected and analyzed under a uniform system that would make the results comparable in all respects, and no country has attempted to publish such a large number of analyses that would be comparable because of the care taken in collecting and analyzing the samples.

Copies of this bulletin may be obtained by addressing the Director of the Bureau of Mines, Washington, D. C.

## A Large Electric Steel Furnace Installation

The American Iron & Steel Company, of Lebanon, Pa., has just closed a contract with Siemens & Halske, of Berlin, Germany, through their representative, Dr. K. G. Frank, of New York City, for what will be the largest single electric furnace installation in the world.

The company has been making an investigation of electric steel-making in this country and Europe and has decided upon the construction of two 20-ton induction furnaces of the Frick type. The furnaces will be of double-ring type and will run on five cycles, single phase, and about 5000 volts. The power requirements will be about 1800 kilowatts each. Two new generators will be installed by the company to serve this need.

**The Pacific Tank and Pipe Company** have moved their San Francisco sales offices from Fifth and Bryant Streets to their old offices, which have been completely refitted, at 318 Market Street, San Francisco.

**Fuller's earth** is the subject of *Bulletin* 71, Bureau of Mines, and deals with the properties, production and preparation of the material for commercial use. Laboratory methods of testing the substance are given.

## Recent Chemical and Metallurgical Patents

### Copper, Lead and Zinc.

**Hydrometallurgy of Copper.**—The accompanying flow-sheet shows diagrammatically the process of Mr. FREDERICK LAIST, of Anaconda, Mont., for the treatment of low-grade copper ores and tailings, in which the metal may be in the form of oxide, carbonate, silicate or sulphide, or in any form in which it may be dissolved and precipitated by $H_2S$. This process has been devised for the treatment of sand tailings at Anaconda, and a commercial-experimental plant of 80 tons daily capacity is now in operation.

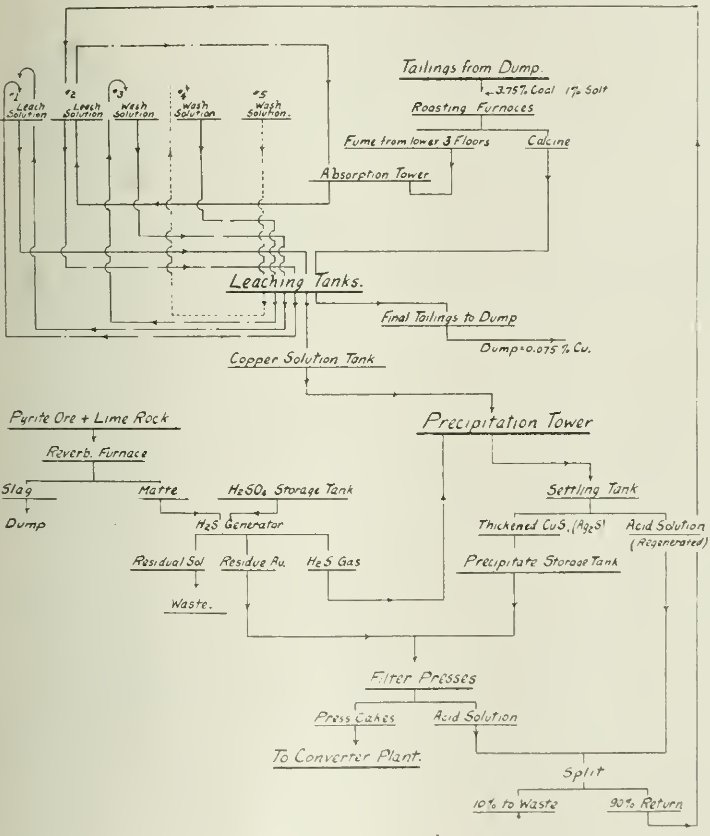


FIG. 1.—FLOW SHEET OF LAIST'S PROCESS

Some of the details of the process, as relating to sulphide ores containing copper and silver, are given herewith. The ore is first subjected to an oxidizing or sulphating roast in a McDougal roaster. The furnace is of special construction. The upper three hearths are devoted to the oxidizing roast, and the lower three to a chloridizing roast, about 1 per cent of salt being added. The resulting products are cupric chloride, silver chloride, ferrous chloride and ferrous oxide. In the chloridizing roasting process some of the copper passes off as fumes of copper chloride, together with some hydrochloric acid. These fumes are drafted to an absorption tower where they are absorbed in water and returned to the leaching solution.

The calcine resulting from the oxidizing and chloridizing roast is leached in vats with a solution of water with about 5 per cent $H_2SO_4$ and 10 per cent NaCl. This solution dissolves the metals, and contains copper chloride, copper sulphate, silver chloride, and certain impurities such as iron and aluminium sulphates and chlorides. The solution is then drained off and precipitated with $H_2S$, yielding a precipitate of copper and silver sulphides. The sulphuric and hydrochloric acids are regenerated and used again. To prevent the accumulation of iron and aluminium salts in the leaching solution, part of it is continuously run to waste.

Sulphuretted hydrogen as a precipitant has certain advantages over electrolysis, in that no expensive equipment is required, and its action is not affected by the ordinary impurities of the solution. The gas is generated from an iron matte or copper-iron matte made by smelting pyrite or pyrrhotite ore, preferably containing gold and silver. This matte is readily decomposed by $H_2SO_4$, yielding $H_2S$. Ferrous sulphate also is formed and wasted. The residue contains the valuable metals, and is combined with the copper precipitated from the solution.

Two leach solutions and three wash solutions are shown in the flow-sheet. These are used in such a manner that the progressive increase in strength of the several wash solutions prevents an undesirable weakening of the leaching solution with which the wash solutions mingle. Various forms of apparatus may be used without affecting the process as long as the successive steps described are followed. (1,076,833, Oct. 28, 1913.)

**Another hydrometallurgical** process for copper, making use also of electrolysis, is that of Mr. HENRY S. MACKAY, of Riverside, Cal. The principal features of this process are (1) the preparation of the solvent ferric chloride, by electrolysis of sodium chloride with iron anodes; (2) the agitation of the ore with this solvent; and (3) the electrolytic deposition of the copper, with regeneration of the active solvent. (1,074,274, Sept. 30, 1913.)

**The use of electrolytic iron** as a precipitant of copper from solution is one of the features of a process patented by Mr. ALBERT DAVID, of Brooklyn, N. Y. The inventor leaches a copper ore with ferric chloride solution, precipitates the copper with electrolytic iron, and passes the impoverished solution to an electrolytic vat in which iron is removed for use as a precipitant. The solvent is regenerated in the process of electrolysis, and returned for further use. Certain auxiliary reagents are used to facilitate both the leaching and electrolysis. One of these is an alkali chloride; another is hydrochloric acid, and a third is a soluble sulphate such as sodium sulphate. If the original ore contains little or no soluble iron, the solution slowly becomes depleted of this metal, and some must be added from an outside source. If an excess of soluble iron is in the ore, some of the metal must be discarded from time to time. (1,075,093, Oct. 7, 1913.)

**Combination Smelting and Converting Furnaces.**—In Fig. 2 is shown a longitudinal sectional view of a combination smelting and converting furnace for the treatment of copper ores, patented by Mr. EMIL KNUDSEN, of Mühlbach, Austria-Hungary. The device is a tilting furnace in the form of a cylinder. At one end the bottom is provided with a recess 1, receiving blast pipes 2. This part of the furnace is of the Bessemer type. The part between the recess 1 and the opposite end 3 is constructed so that the bottom slopes toward the recess. There are two top openings, as shown, one being numbered 4 and the other 6. Number 6 is out of alignment radially with the opening 4, so that when the furnace is tilted molten material will escape through 4 without discharging anything through 6. In operation the ores charged through 6 are smelted and run onto the Bessemer recess 1, where copper is produced in the usual manner. (1,075,214, Oct. 7, 1913.)

Another form of furnace designed for similar purposes is shown in side elevation in Fig. 3, being the invention of Mr. GEORGE MITCHELL, of Los Angeles, Cal. It consists of a smelting hearth 2 and a converter 3, the latter being located at one end of the furnace. At the opposite end is the stack and a steam boiler adjacent the stack if desired. Burners for oil or gas are located at 6. After smelting has progressed up to the point where there is sufficient matte to convert, the heat generated in that process will be of material assistance in carrying on the smelting operation. (1,074,282, Sept. 30, 1913.)

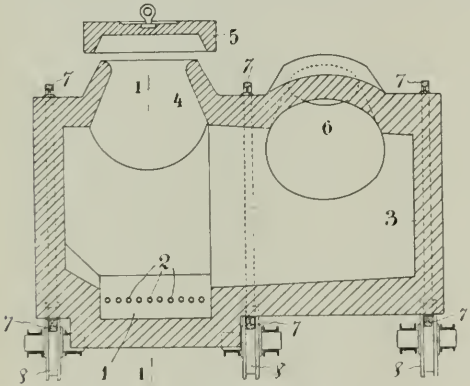


FIG. 2.—KNUDSEN COPPER FURNACE

**Zinc Smelting Under Pressure.**—Various attempts have been made to smelt zinc ores in cupola furnaces, but have generally been unsuccessful. The vapor of metallic zinc has been reoxidized before it could be collected, and the fluxing materials have prevented precipitation. According to a patent granted to Mr. ELISHA B. CUTTEN, of Erie, Pa., the inventor proposes to smelt zinc oxide free from gangue, and effect the reduction in a low blast furnace in a reducing atmosphere under pressure. Zinc oxide, produced by some suitable process, is briquetted with fuel, charged into a furnace heated by gaseous or liquid fuel, and smelted under a pressure of from 20 to 60 lb. per sq. in. The fuel is injected in such quantity as to produce reducing conditions. The furnace would be operated intermittently, and metallic zinc drawn at the end of the operation. (1,080,102, Dec. 2, 1913.)

**Chloridizing Complex Ores.**—A modification of the general proposal to chloridize complex sulphide ores by treatment with dry chlorine, is patented by Mr. TORMOD R. FORLAND, of Broken Hill, N. S. W., Australia. The inventor has discovered that volatilized chlorides can be separated by fractional condensation, and he proposes subjecting the distilled chlorides to successively lower temperatures, thereby separating the metal salts. Thus, lead chloride would condense at a temperature just under 900° C., zinc chloride just under 730°, etc. The fractions would be collected in a molten state or as sublimate in several condensers, and would be removed for electrolysis. The end products would be metals and chlorine, the latter being returned to the treatment for more ore. By varying the temperature of the distilling furnace, various fractions could be driven off and condensed. (1,078,779, Nov. 18, 1913.)

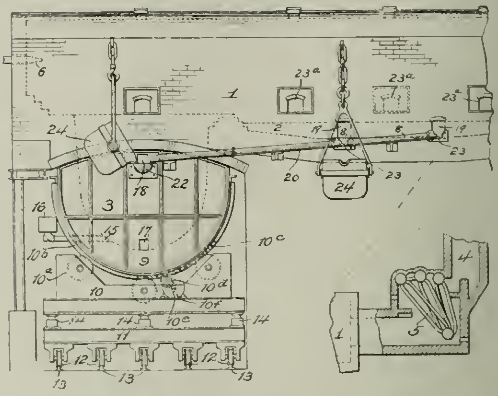


FIG. 3.—SMELTING AND CONVERTING FURNACE

### Metallurgical Furnaces.

**Heating Furnace.**—An improvement in furnaces of the type used for heating metal bars or rods, is shown in Figs. 4 and 5, being the invention of Mr. WALTER S. ROCKWELL, of New York City. One object of the invention is to utilize the waste heat of the escaping gases to preheat the air used for combustion, and to construct this preheater in the form of a shield to protect the operator. The figures show a furnace with a heating chamber 1 and working opening 2. Heat is supplied through burners 10 on each side of the chamber, fuel being delivered to the burners through pipes 11. Air is

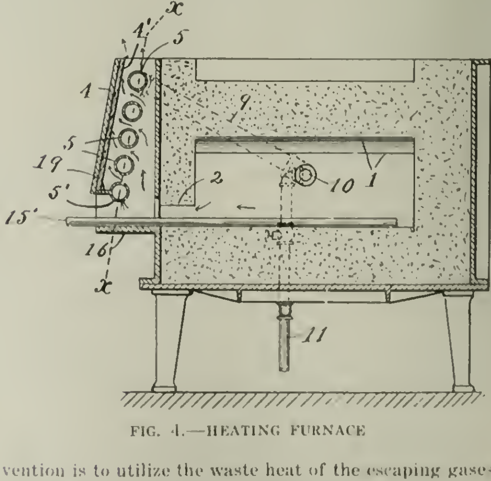


FIG. 4.—HEATING FURNACE

supplied to the burners through pipe 8, passing first through pipes 5 connected at their ends with headers 6, 7. A shield 4 is placed in front of pipes 5, and the entire arrangement of shield, headers and pipes forms a preheater for air and a protection to the operator. Hot air issues from the preheater through pipes 9 leading to the burners. (1,079,266, Nov. 18, 1913.)

### Iron and Steel.

**Reduction of Ores.**—The specifications of a patent recently granted to MR. JAMES A. MCLARTY, of Toronto, Ontario, Canada, disclose the inventor's idea of reducing oxide ores by subjecting them to the action of reducing gases at a temperature below a red heat. In carrying out his process he supports the ore on a suitable grate above a bed of incandescent coke. Air is admitted freely to the coke fire, so that the product of combustion is practically all $CO_2$. At a point between the bed of fuel and the grate supporting the ore, he injects a spray of a liquid or gaseous hydrocarbon, or a finely powdered carbohydrate, or any other material that will reduce the $CO_2$ to CO and yield hydrogen. The temperature of the gas falls during this reaction, but is still high enough (750-800°F.) to permit reaction with the ore. The reaction takes place at a temperature above that at which sulphur and similar impurities will sublime from the ore, but below that at which sulphur or carbon will combine with the iron. Apparently the product of the reaction cannot be molten, and although the specification does not mention the physical condition of the product, it may be assumed to be "metallized" in solid form. (1,079,788, Nov. 25, 1913.)

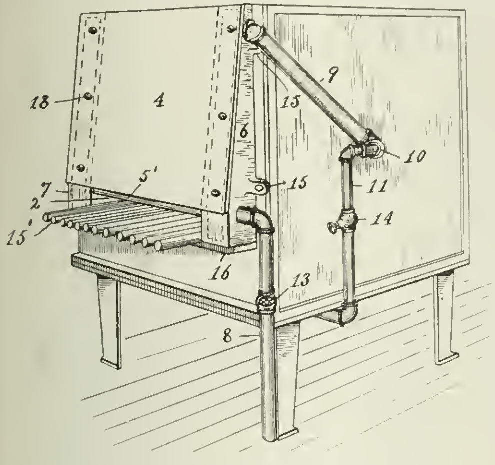


FIG. 5.—HEATING FURNACE

**Nodulizing Kiln.**—A form of kiln for nodulizing iron ores, in which the formation of sintered rings of ore is said to be prevented, is the subject of a patent granted to MR. LEWIS P. ROSS, of Standish, N. Y. The kiln is of the usual rotary-tube type, inclined to assist the travel of ore from feed to discharge, and being fed with finely divided ore at the upper end and with a fuel flame at the lower. The point of distinction lies in the fact that the lower end of the kiln, about one-third of the total length, in which the adhesive rings of ore usually form, is separate from the upper portion, and whereas the upper portion rotates continuously, the lower part is merely oscillated, being actuated by a reversible motor. The result of the oscillatory action is that the adhesions of ore form in the shape of a crescent instead of a full circle. The thickest part of the adhesion being at the top of the kiln, the mass falls of its own weight and thus removes the obstruction. (1,076,705, Oct. 28, 1913.)

### Gold and Silver.

**Filter-Leaf and Method of Dislodging Cake.**—In two patents granted to MR. CHARLES BUTTERS, of Oakland, Calif., the inventor suggests improvements in the construction of vacuum filter-leaves, and in the method of discharging the filter-cake from them.

The new form of filter-leaf consists of a rectangular frame of wooden members, in which shallow channels are formed on each face for receiving wooden strips by which the filter cloth is secured to the frame. The central pervious member of the filter is cocoa matting, and the outer filtering medium is drilling of light weight. In making the filter, a sheet of drilling is first attached to one side of the frame by means of the wooden strips inserted into the grooves or channels, and held in place by tacks or nails. Then the cocoa is laid in the frame, and the other filter cloth attached on the opposite side of the frame. Vertical strips of wood spaced at equal intervals along the opposite faces of the leaf are held in place by metal holders on the wooden frame, and are bolted together at their mid length. These serve to give rigidity to the leaf. The method of construction is simple, and avoids the necessity of stitching a filter bag in the usual manner. The leaf is easily demountable, and thin, relatively cheap filter cloth can be used, discarded and renewed at frequent intervals.

The improved method of dislodging the filter cake is apparently an effort to get away from the use of compressed air or liquid applied to the inner surface of the filter, in a direction reverse to that of filtration. Each filter leaf is provided with a header pipe, perforated on its under side with ¼-in. holes 3 in. apart, and supported well above the vacuum header. Through this perforated pipe water can be forced under pressure and caused to flow downward over the filter cake, thereby causing it to fall from the filter cloth. It is essential to the easy operation of this method that the filter cloth be smooth and that the cake be as dry as it is possible to make it by vacuum. In operation, after the cake has been formed and washed, it is suspended in air, and the full vacuum is applied for five or ten minutes. This will reduce moisture to about 20 per cent, and induce cracking of the cake. Thereupon the vacuum is cut off and water is applied through the header pipe mentioned. The cake is dislodged in from one to three minutes, and the filtering surface is thoroughly washed. (1,078,994, Nov. 18, 1913.)

**Sterling Silver.**—A new formula for sterling silver is patented by MR. EDWARD D. GLEASON, of New York City. The feature of the formula is the use of boron to give hardness to the resulting alloy, and to remove occluded gases so that castings of the metal will be free from imperfections. The boron is first incorporated with copper, and then this mixture is added to silver. The inventor claims a sterling silver containing from .900 to .925 silver and from .75 to .100 copper and boron. (1,075,642, Oct. 14, 1913.)

### Miscellaneous.

**Production of Phosphoric Acid.**—An improved method of extracting phosphoric acid from natural phosphates consists, according to specifications of patents granted to MR. MAXIMILIAN M. HAFF, of Ottawa, Canada, in subjecting finely pulverized phosphate with clay to electric heat, and recovering the volatilized acid by fixing it with an alkali. The clay used is ordinary blue clay, and it is used in the ratio of 60 parts clay to 100 parts phosphate. The clay and phosphate form a fluid clag under the heat from the electric arc, and the acid is volatilized. No reducing action takes place, and is preferably prevented. (1,076,497-9, Oct. 21, 1913.)

**Metallic Manganese from Ores.**—Mr. Friedrich Heusler, of Dillenburg, Germany, has patented an improved method of extracting manganese from its ores. According to former methods of production, manganese ores were fluxed with lime and with reducing agents such as soot, oil or the like, and heated in a graphite crucible. The yield of manganese is low. The inventor has found that he can obtain a yield within 90 per cent of the theoretical by first calcining a part of the ore, thereby increasing the relative proportion of manganese, and then mixing some of the calcined ore with crude ore, fluxing and reducing as before. The proportions may be varied, but preferably are not below 20 per cent for the crude ore and not above 80 per cent for the calcined product. (1,078,199, Nov. 11, 1913.)

**Solder for Aluminium.**—A formula for aluminium solder, patented by Mr. Charles Willmott, of Smethwick, England, consists of a mixture of 86 per cent tin and 14 per cent bismuth.

**Production of Alkali Metals.**—The decomposition of alkali cyanides for the production of sodium and potassium is patented by Mr. John E. Bucher, of Coventry, R. I. The inventor has discovered that if cyanides of sodium and potassium be heated with iron, or distilled through or in contact with incandescent iron, the cyanides are decomposed, yielding alkali metal and nitrogen. The carbon combines with the iron. (1,079,974, Dec. 2, 1913.)

**Radiothorium.**—Thorium minerals contain a radioactive substance, just as uranium minerals contain radium. In the process of manufacturing Welsbach mantels, a by-product known as meso-thorium is obtained. From this material a radioactive substance can be developed, known as radiothorium. Mr. Lise Meitner, of Berlin, Germany, has patented an electrolytic process of producing radiothorium, consisting in the electrolysis of an acid solution resulting from the extraction of residues from the preparation of mesothorium. Radiothorium separates at the cathode in a relatively pure state. (1,076,141, Oct. 21, 1913.)

**Recovery of Dust from Cement Kilns.**—The dust escaping from cement kilns constitutes a loss of cement-making material, and is undesirable from many other points of view. The difficulty of collecting this dust arises from the high temperature of the gases, thereby eliminating the possible use of bags, as in smelter practice. Washers and the like introduce complications in the draft through the kilns, and have been unsatisfactory. Messrs. Rolla C. Carpenter, of Ithaca, N. N., and Thomas J. Fleming, of Los Angeles, Cal., have patented a process of producing draft in kilns and separating the dust from the waste gases. The dust collecting means consists of houses or structures composed of material having a high rate of heat conductivity and a large radiating surface. In these structures are hung numerous vertical wires or rods, forming a grill to intercept the dust particles. When the dust-laden gases are introduced into the structure, their velocity is greatly decreased, and the solid particles settle out by gravity. This general method has been used in smelting works with great advantage. In order not to interfere with the draft in the kilns, fans are placed between the kilns and the dust-houses. (1,078,254, Nov. 11, 1913.)

---

**Transvaal Gold Production.**—The number of companies reporting to the Transvaal Chamber of Mines in July, 1913, was 62. The quantity of ore milled during that period was 1,913,327 tons. There were 10,015 stamps in operation, with an average duty of 8.54 tons per 24 hours. Tube mills in commission numbered 287. The yield for the month was 655,389 fine ounces gold. The report shows the steadily increasing stamp duty due to the greater number of tube mills used.

## Oxy-Acetylene Welding and Cutting

In connection with the recent New York convention of the American Society of Mechanical Engineers, the Davis-Bournonville Company gave on the afternoon of Dec. 4, to a large number of members of the society, a very interesting series of demonstrations and exhibitions illustrating the development in the oxy-acetylene and oxy-hydrogen processes of welding and cutting metals.

The program included demonstrations of acetylene generation, oxygen generation, welding and cutting torches, cutting steel risers and cutting rivet heads, welding boiler plates and tubes, cast-iron molding, aluminium, brass and copper welding.

A barrel welding machine was exhibited which attracted considerable attention, as did also the emergency equipment. The latter is a small complete outfit, handled easily by two men. The outfit is particularly useful in fire department work, train wrecks, etc. Six cuts were made through bars of iron about 1 in. square in less than two minutes. Among other features was the cutting of a piece of armor plate 16 in. thick with the oxy-hydrogen radiograph.

---

## Laboratory Mill

We have received from Ernst Grunbach & Sohn in Freiberg, Saxony, Germany, a prospectus of a laboratory mill developed by this firm in conjunction with Dr. Th. Koerner.

As shown in the adjoining illustration, the frame of the mill proper is a cast-iron ring closed on both sides by circular plates, one of which is removable for the sake of inspection. The inner periphery of the ring is provided in its upper part with ribs, while a removable screen is placed at the bottom.

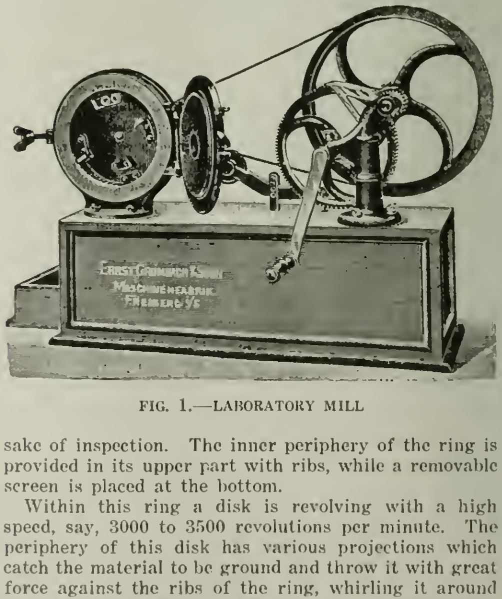


FIG. 1.—LABORATORY MILL

Within this ring a disk is revolving with a high speed, say, 3000 to 3500 revolutions per minute. The periphery of this disk has various projections which catch the material to be ground and throw it with great force against the ribs of the ring, whirling it around until it is disintegrated sufficiently to drop the screen in the bottom.

For cleaning, the mill is opened as shown in the illustrations and the revolving disk is taken out.

An essential element of satisfactory operation is a sufficiently high speed. This is most conveniently obtained by driving the mill with an electric motor.

---

The **Bridgeport Testing Laboratories** announce the removal of their office and industrial chemical laboratory to 388 John Street.

## A New Electrolytic Process for the Production of Flat Perforated Copper Tubing for Radiators

The Electrolytic Products Company of New Jersey, manufacturers of automobiles and house radiators, condensers, tubing, etc., at 75 Clinton Street, Newark, N. J., have just put on the market articles made up of hollow perforated copper tubing produced by a novel and decidedly interesting electrolytic process of their manager, Mr. F. A. Feldkamp. (U. S. Patents 1,055,324, March 11, 1913, and 1,071,036 and 1,071,037, of August 26, 1913.)

Fig. 1 shows an automobile radiator made up of such flat perforated copper tubing and Fig. 2 shows samples of this tubing. The structure of this tubing will be best understood if we first describe merely the chief steps in its manufacture.

A flat lead strip, say of ⅛ in. thickness and perforated at intervals with ¼ in. holes staggered with reference to each other, is electroplated with copper, and the strip is then cut into suitable lengths. These are heated above the melting point of lead; the lead core is thereby melted out. What remains back is the copper plating in form of a light copper tubing of an internal contour corresponding to the original perforated lead strip.

Tubing of this structure is shown in Fig. 2. It is a flat, hollow tubing, the distance between the two parallel flat surfaces being equal to the thickness of the former lead strip (⅛ in.). Where there were the holes in the lead strip, there are now little copper cylinders (diameter ¼ in.) holding the two flat sides of the copper tubing together. This method of construction greatly strengthens the tube against internal or external pressure.

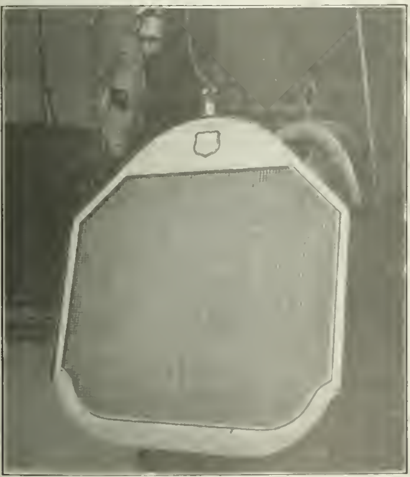


FIG. 1.—AUTOMOBILE RADIATOR

The thickness of the copper walls of the tubing can, of course, be easily adjusted by extending or reducing the time of the electroplating operation. Tubes with walls 0.006 in. thick easily sustain a pressure of 15 lb. per square inch.

As far as the lead is concerned, this is used over and over again, and it may simply be stated that in practice no difficulty whatsoever has been experienced in removing the molten lead out of the copper plate structure. For this reason the process may be called the "plomb-perdu" process.

The chief interest of the process lies in the electroplating operation. This has been made continuous and automatic, the lead passing in form of a long strip through the plating bath. The time during which it is in the bath (or, what is the same, the speed with which the strip is passed through the bath) is so adjusted that a deposit of the desired thickness is obtained.

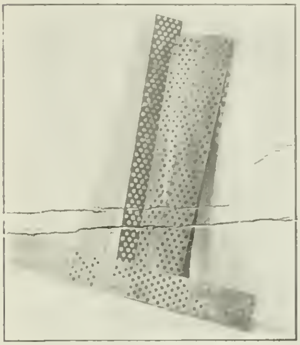


FIG. 2.—HOLLOW PERFORATED COPPER TUBING FOR RADIATOR

The plating bath has a length of 25 ft. One inch of tubing intended for automobile radiators leaves the bath every minute. For thinner tubing, such as used in aeroplane construction, 2 in. of tubing leave the bath every minute.

The chief striking feature of the process is in the anodes. These are in form of wires. The lead strip passes in vertical position and in horizontal direction through the plating bath. On each side of the lead strip there are a number of copper wires above each other, forming the anodes; they also pass in horizontal direction through the plating bath so that they enter the bath with a certain thickness and leave it with a smaller thickness. The wire strands travel through the electrolyte in the same direction of the band from one end of the bath to the other end and then back again.

The arrangement of the several wires is such that at the place of the heavy in-passing wires, there will also be thin out-passing wires. At any point across the series of moving wires within the electroplating tank, the reduction of the wires is such that the sum total of the cross-sectional areas of all the wires always remains the same. Thereby an absolutely uniform deposit from the wire anodes constantly moving through the electrolyte and out again is obtained.

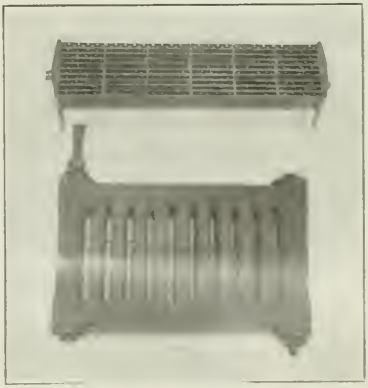


FIG. 3.—COPPER RADIATOR AND IRON RADIATOR FOR HOUSE HEATING

But the use of wire anodes has another important advantage. In the usual electroplating process there is always a loss of anodes in the form of scrap. This often amounts to 50 per cent of the weight of anodes. With this wire anode arrangement not only no anode scrap is produced, but the relative value of the wire is even increased, because thin drawn copper wire is relatively more expensive than thick wire.

The practice of the company is to use wire of No. 8 B. & S. gauge as in-passing wire and let it leave the plating tank as No. 20 B. & S.

Tests of radiators made of this hollow perforated tubing show that they can be built to stand abuse and vibration on automobiles. As to the use of such radiators for ordinary house heating, their very compact form and light weight is a decisive advantage. Fig. 3 shows, for the sake of comparison, a copper radiator of this type and an ordinary iron radiation for house heating. The radiating surface of the copper radiator is 7.52 sq. ft., that of the iron radiator is 7 sq. ft., so that both are about the same. But the weight of the copper radiator is only 3 lb. 6 oz., that of the iron radiator is 48 lb.

Tests of condensers made of this hollow perforated tubing have shown that it is possible to build a condenser that will operate with 8.5 lb. of water per pound of steam, while usually 13 lb. of water per pound of steam is considered excellent and 20 not uncommon.

The manufacturers estimate that they can build a 100-hp condenser exclusive of air pump weighing 30 lb. for the condenser and probably not more than 100 lb. for the containing tank at a greatly reduced cost in comparison with usual constructions.

This tubing may also be used in the arts pertaining to apparatus and devices for electrical, chemical and electrochemical purposes.

While not embodying anything of a revolutionary character, the process is decidedly pretty in its conception and the details have been carefully worked out.

## Laboratory Vacuum Cleaning

In many chemical laboratories a vacuum pump is available for various uses in connection with blow lamps, sand blast, agitation, testing, etc., and the object of this note is to describe the application of the vacuum pump to vacuum cleaning of the laboratory. This is a simple matter, as all that is required is the ordinary dust-separating tank, suitable lengths of pipe or hose, and the cleaning tools.

Fig. 1 shows an illustration of how a simple separating tank can be constructed. This is made of an ordinary 40-quart milk can which may be easily procured at the expense of a couple of dollars. The cover of this can forms an airtight tank and, therefore, is especially adapted for this work. A round hole is cut in the cover and a pipe connection made as shown in detail in the sketch. The pipe or hose connecting the tank with the cleaning tool is attached at this connection.

The connection from the can to the pump is made at the bottom in the same manner as above. This can is to act as a screen and to prevent the dust and dirt from entering the pump, and it, therefore, becomes necessary to provide a screen in the can to catch the dust and dirt. This is provided for by means of a bag made in suitable shape to set into the can about three-fourths of the way down, and made to rest over the neck of the can in such a manner that the cover will be drawn down over the top, holding it secure. This bag may be made of some suitable material such as canvas, canton flannel or suitable silk bolting cloth, depending on the amount of dust and dirt to be removed. The connection to the pump is made by means of pipe nipple and a union.

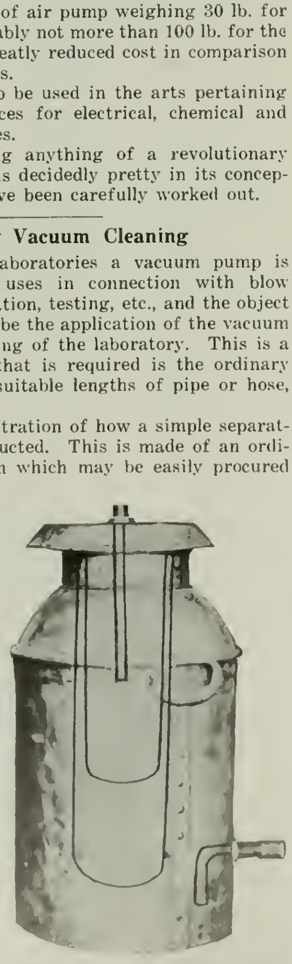


FIG. 1—SEPARATING TANK FOR VACUUM CLEANING

The machine is now ready for operation after attaching a belt to the pump from the motor or a line of shafting.

If the dirt thus taken up contains valuable metals—and this happens often enough in laboratories—they are easily recovered in this manner.

Fig. 2 shows a vacuum pump made by Leiman Brothers, 62 John Street, New York City, specially for laboratory work. These pumps may be procured separately and the balance of the outfit assembled by anyone with any ordinary mechanical ability, or the entire outfits may be secured and the proper connections made. The pipe for blowing can be led from the pump to where the air blast is required and used as stated above for the various purposes in connection with the regular laboratory work.

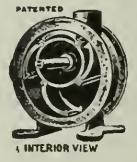


FIG. 2—VACUUM PUMP

## Monel Metal

From Philadelphia comes the report of the consolidation of two of the oldest and most prominent hardware companies into a new corporation to be known as the Supplee-Biddle Hardware Company. The combining firms are the Biddle Hardware Company and the Supplee Hardware Company. The new concern is incorporated for $1,000,000, and will be the largest wholesale hardware distributing house along the Atlantic. Mr. Charles M. Biddle is the chairman of the board.

The corporation will occupy seven buildings, eight stories high and covering about six acres. One entire floor will be given up to Monel metal to the many uses of which the corporation will pay special attention.

As is well known, Monel metal is a "natural alloy" of metal and copper, produced by reduction from the Sudbury nickel-copper ores. It consists approximately of 68 per cent nickel and 30 per cent copper, the balance of 2 per cent being iron and manganese. It has a tensile strength of from 70,000 to 100,000 lb. per sq. in.—greater than bronze and equal to mild steel. It can be easily machined. But perhaps its most characteristic feature is its resistance to corrosion.

Wherever corrosion is a menace, Monel metal rods are proving their superiority over other metals. In pump rods, piston rods, shaftings, valve stems, machine bolts, etc., Monel metal outwears bronze rods by 50 to 100 per cent.

Monel metal pump rods are impervious to superheated steam, do not gather verdigris, and retain a smooth, glassy surface which reduces friction to a minimum and gives greater economy in power.

The Supplee-Biddle Hardware Company cite the experience of a coal-mining concern that placed an order for Monel metal special chute plates some time ago for use in loading gondola cars at their mines. As soon as these chutes were put into use they discovered that the smooth surface of Monel metal obviated the usual choking of coal and that better results and more even loading could be made at a greatly reduced angle of elevation or pitch. Moreover, experience appears to show that coal chutes of Monel metal will outlast steel coal chutes several times over.

To the manufacturer who has lost time and money in a vain attempt to keep acid, salt pickle, tanning or chemical vats and tanks in condition with corrosion eating away his tie rods as fast as they can be replaced, Monel metal tie rods come as a great boon. Monel metal is being used for tie rods of all lengths and descriptions with great success.

Monel metal is also used for valve stems and wire cloth. Screen wire cloth of Monel metal, made by the Biddle Hardware Company, is used for window screening in the city of Colon at the Panama Canal operation. It is the only material the Government has found that will stand the climatic conditions of that territory.

For mines, railway work, chemical plants, sewage disposal plants and engineering operations where ordinary screens are quickly eaten away, Monel metal wire cloth gives splendid service. It has great tensile strength and railway or mine gases do not affect it.

One of the largest developments of the past year has been the successful forging of Monel metal up to 1000 and 2000 lb. Where bronze forgings are now used Monel metal forgings can be substituted. They have the advantage of being non-corrodible and in addition possess all the good qualities of bronze. Owing to the superior strength of Monel metal, lighter forging than bronze can be used unless a large size is essential. The cost of Monel metal forgings will average no more than bronze forgings, and in many cases the cost will be less.

Castings of Monel metal for many purposes have been made for some time, and the ability to make forgings of this metal is of great interest to the manufacturing world. For example, valve rings and seat disks and seat rings of castings are at the present time in extensive use. The Supplee-Biddle Hardware Company is now able to make forgings of disks and seat rings and also valve spindles by this method. In fact, many forgings of steel or bronze can now be duplicated in Monel metal.

Through the use of Monel metal corrugated gaskets the joint can be made as tight and as permanent as any other part of the line.

For use in exposed places where strength is essential and both flexibility and rust-resisting qualities are necessary, Monel metal ropes will give the maximum service and satisfaction.

## Personal

Mr. **Luther B. Eames** has been appointed superintendent of the mill of the Goldfield Consolidated Mines Company, Goldfield, Nevada, and has assumed the duties of his position.

Mr. **H. N. Spicer** was married on November 17, 1913, to Mrs. Laura M. Stoiber. Mr. Spicer is in charge of the New York office of the Dorr Cyanide Machinery Company, and is residing at 12 Fifth Avenue, New York City.

Mr. **H. R. Conklin**, manager for the Lluvia de Oro Mining Company, Lluvia de Oro, Chihuahua, Mexico, was in Denver recently. He is spending some time in the States pending the settlement of troubles in Mexico, which have necessitated closing the property.

Mr. **B. B. Thayer**, president of the Anaconda Copper Mining Company, has been nominated for the presidency of the American Institute of Mining Engineers.

Mr. **Herbert Haas**, of San Francisco, has been appointed metallurgical engineer to the United States Bureau of Mines.

Mr. **C. C. Ferguson**, formerly with the Oliver Iron Mining Company, has been appointed consulting engineer to the Iron Mountain mine on the Cuyuna Range, Minnesota.

Mr. **Robert C. Sticht**, general manager for the Mount Lyell Mining and Railway Company, Tasmania, expects to make a tour of the world. He is expected to leave Australia this month.

Prof. **Robert H. Richards**, of Boston, was a witness in the recent litigation proceedings between the owners of Wilfley and Deister table patents, held at Indianapolis. Mr. **A. R. Wilfley** also was in attendance.

Mr. **Sidney J. Jennings**, vice-president in charge of exploration and mine investment for the United States Smelting, Refining and Mining Company, recently inspected the companies' Utah properties.

Mr. **George F. Waddell** has resigned his position as superintendent of the concentrator of the Steptoe Valley Smelting and Mining Company, McGill, Nevada, to become general manager for the Ohio Copper Company, Bingham and Lark, Utah.

Prof. **G. A. Roush**, of Lehigh University, has been appointed editor of *Mineral Industry*.

Mr. **Richard K. Meade**, consulting chemical, mechanical and industrial engineer, 202 N. Calvert Street, Baltimore, Md., has been retained by the Louisville Cement Co., to prepare plans for their new hydrated lime plant, at Mill Town, Ind. This plant will have a capacity of 60 tons of hydrate per day and be equipped throughout with the most approved appliances for the manufacture of hydrated lime. The plant will be located alongside of their new gas fired kilns on the opposite side of the river from their present hydrated lime plant.

Mr. **John Bellamy Taylor**, formerly with the General Electric Company, has opened offices as consulting electrical engineer at 23 Lowell Road, Schenectady, N. Y., and 100 Broadway, New York.

## Digest of Electrochemical U. S. Patents

PRIOR TO 1903.

*Arranged according to subject-matter and in chronological order.*

*Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.*

### REFINING METALS (*Continued*).

589,251, Aug. 31, 1897, John Oliver Surtees Elmore, of Kapurthala, India.

Relates to the refining of metals by electrolysis, and consists of a plurality of superimposed horizontal cells made by assembling a large cathode sheet, a wood frame resting on its edges, an anode of impure metal within the frame resting on the cathode, another cathode sheet, another frame and anode, etc., until as many as are wanted have been built up. The cathode sheets are perforated at one end within the frame, the perforations alternated in successive sheets. The assembled cells are suitably bolted together to prevent leakage. Electrolyte flows through the cells in a zigzag course and out of the bottom; it may be filtered when desired; it then flows into a "rocking trough" which empties first into one side, then into the other, of a large tank, and thereby serves to mix it; from the tank it is pumped to the top of the cells; the rocking-trough further serves to prevent a short-circuit. The current dissolves the anode and deposits the metal on the lower side of the cathode sheet above, the anode and cathode sheet constituting secondary electrodes.

589,252, Aug. 31, 1897, John Oliver Surtees Elmore, of Kapurthala, India.

Relates to the refining of metals, and consists of an apparatus constructed on the principle of that in his prior patent 589,251, except that the electrodes are vertical instead of horizontal; thereby forming vertical cells. The anode constitutes a secondary electrode, the electrolyte passing through in a zigzag course. The electrolyte passing out of the cell empties into a "rocking trough" as described in his prior patent.

592,097, Oct. 19, 1897, Bernard Moebius and Gustav Nebel, of New York, N. Y.; said Nebel assignor to said Moebius.

Relates to improvements in apparatus for carrying out the process of electrolytic separation of silver described in U. S. patent 532,209, to Bernard Moebius. In said process it was found that the silver deposited tended to adhere to the belt, requiring scraping and resulting in injury to the belt. This tendency to adhere is overcome by continuously oiling the surface of the belt upon which the silver is to be deposited, which oiling efficiently prevents adhesion of the silver to the belt. The silver belt is also used to convey the deposit out of the tank, instead of transferring it to a separate conveying belt within the apparatus, as in the earlier patent.

593,837, Nov. 16, 1897, George E. Dunton, of Boston, Mass.

Relates to apparatus for continually circulating and thoroughly agitating all kinds of liquids, and especially adapted for electrolytic baths. Located within one corner of a tank is a centrifugal pump having an inlet strainer near the lower end of a suction pipe and an outlet pipe leading from the pump casing to the top of the tank on the opposite side at a point below the level of the liquid contained in the tank. The pump draws the heavy solution through the strainer from one corner at the bottom but without disturbing the sediment on the bottom of the tank, and discharges through an outlet on the opposite side near the top, causing the solution to take a circular motion around and between the anodes and cathodes.

614,633, Nov. 22, 1898, Friedrich A. Thum, of Newark, N. J.

Relates to apparatus for refining metals or extracting metals from ores, slimes, scrap metal, etc., the apparatus operating upon the series, or secondary, electrode principle. A series of racks are placed side by side within a tank at the ends of which are the principal anode and cathode. The racks consist of a frame having a set of spaced bars connecting the ends, and dividing the frame vertically into two halves, one of which is a receptacle for a raw-material container, and the other affording space for the electrolyte. The container consists of a box-like structure having a muslin bottom, which is placed in the frame with the muslin against and supported by the spaced bars. The container is now filled with the slimes or scrap metal, or ore, and against this is placed a metal or carbon plate held in grooves in the frame. The assembled frames are placed in the tank of electrolyte, and so connected that the scrap dissolves as anode and deposits upon the side of the metal or carbon plate of the next frame. The scrap, etc., may be replenished as desired through an opening in the frame.

617,526, Jan. 10, 1899, Elisha Emerson, of Buffalo, N. Y.

Relates to refining metals and depositing the metal as a tube, etc. The improvement is in the anode, which consists of supports of lead or other insoluble conductor, shaped so as to be concentric to the tube being deposited, and upon which (the lead supports) are secured the anodes of copper or other metal to be refined. The copper, etc., is in the shape of bars, which are held in lugs upon the lead supports.

617,886, Jan. 17, 1899, Elias A. Smith, of Anaconda, Mont.

Relates to purifying an impure electrolyte resulting from electro-refining crude copper. Such an electrolyte soon becomes so burdened with arsenic and antimony as to be unfit for further use. It is customary to evaporate it until sulphate crystals form, then run the mother liquid to waste. In the present invention, this mother liquid is still further concentrated in shallow lead pans until the iron salts present have crystallized out, and the specific gravity reaches about 55° Be. The liquor is then run out and cooled, a further deposit of copper sulphate crystals are then obtained, and the excess of liquor removed. To this excess liquor is added crystals of calcium or sodium thio-sulphate, which effect the precipitation of the arsenic and antimony and liberate a supply of sulphur dioxide which remains dissolved in the liquor, which is advantageous in the electrolyte by reducing the remaining iron to the ferrous state, and also retarding the oxidation of the arsenic to copper arsenate as the anode dissolves. After the removal of the arsenic, antimony and other precipitates, the electrolyte may be reused.

625,863, May 30, 1899, Emil Wohlwill, of Hamburg, Germany.

Relates to the refining of gold and gold alloys, using an electrolyte of gold chloride and hydrochloric acid. Prefers to use a solution containing 25 to 30 grams of gold per liter, and from 20 to 50 cubic centimeters of hydrochloric acid of specific gravity 1.19 per liter, at a temperature of from 60° to 70° C. Hydrochloric acid is added to replace that lost, and gold chloride is added periodically to keep a constant per cent in solution. The presence of platinum does not interfere; palladium in quantities of 5 drams per liter does not interfere. Silver accumulates on the anode as silver chloride and may be removed mechanically. In the presence of lead sulphuric acid may be added to the electrolyte to form lead sulphate, which should be removed from the anode. Bismuth may form a precipitate of oxychloride in the absence of sufficient acid. An anode 4 millimeters thick will be nearly consumed in twenty-four hours with a current density of 400 amperes per square meter. The deposited gold is pure.

---

## Book Reviews

**Zink und Cadmium, von R. G. Max Liebig.** 16x23 cm., 598 pages (no index), 205 illustrations, 10 plates; price, bound, 32 marks. Leipzig: Otto Spamer.

At last, German technology has a treatise on the metallurgy of zinc. Professor Schnabel handled it well in his "Handbuch der Metallurgie," but a separate, exhaustive treatise was badly needed. Prof. Dr. F. Fischer, of Göttingen, needed this treatise as part of his collection of books on "Chemische Technologie," and asked the works manager, Max Liebig, to write it. The latter had been in zinc works for nearly a lifetime, and having retired found he had the leisure and the materials wherewith to write the book.

The work handles systematically, completely, and clearly every branch of the metallurgy of zinc. Electric zinc furnaces and electrolytically obtained zinc are satisfactorily written up; in fact, throughout the book, the completeness of the treatment is noticeable and commendable. If the very latest practice of zinc works is in some cases omitted, it is simply because the works refuse to allow it to be published. The *rationale* of the condensation of zinc vapor mixed with other gas is correctly explained on the principle of partial vapor tensions, but instead of this being credited to Roitzheim's publication in *Metallurgie*, in 1910, it should be credited to Richards' "Metallurgical Calculations," Part III, published in METALLURGICAL AND CHEMICAL ENGINEERING (often called Electrochemical and Metallurgical Industry), in 1908.

There are now three treatises on the metallurgy of zinc: that in English, by Ingalls is most complete on the side of American practice; that in French, by Lodin, is most complete on the side of Belgian practice; the German work of Liebig is the most comprehensive book of the three, and should be possessed by every one having any particular interest in any branch of the metallurgy of zinc.

# Metallurgical and Chemical Engineering

A Consolidation of ELECTROCHEMICAL AND METALLURGICAL INDUSTRY and IRON AND STEEL MAGAZINE

VOL. XII NEW YORK, FEBRUARY, 1914 NO. 2

PUBLISHED MONTHLY BY THE
McGraw Publishing Company, Inc.
JAMES H. MCGRAW, President.
C. E. WHITTLESEY, Secretary and Treasurer.
239 West 39th Street, New York.
TELEPHONE CALL, 4700 BRYANT.
CABLE ADDRESS, METCHEM, NEW YORK.

WESTERN OFFICE..................421 Boston Bldg., Denver, Colo.
CHICAGO OFFICE..............................Old Colony Building
PHILADELPHIA OFFICE................Real Estate Trust Building
LONDON OFFICE..............Hastings House, Norfolk St., Strand

E. F. ROEBER, PH.D., Editor.
H. C. PARMELEE, Western Editor.

J. M. MUIR, Manager.

*Yearly subscription price for United States, Mexico and United States dependencies,* **$2.00;** *for all other countries,* **$2.50.** *(European exchange, 10 shillings, 10 marks, 12.50 francs.)*

Copyright, 1913, by the McGraw Publishing Company, Inc.

Entered as Second-Class Matter at the Post Office at New York, N. Y., under the Act of Congress, March 3, 1879.

NEW YORK, FEBRUARY, 1914

CONTENTS.

EDITORIAL:

Æsop at Niagara Falls.......... 71
Keeping Posted.......... 71
The Power Problem in Electrochemistry.......... 72
Steel Costs and Selling Prices.......... 72
Custom Cyanide Mills.......... 72
The Government's Trust Program.......... 73

READERS' VIEWS AND COMMENTS:

Relative Thermal Conductivity of Silica and Clay Brick. By S. M. Marshall.......... 74
The Induction Furnace for Steel Refining. By Ivar Rennerfelt.......... 74
Hydrometallurgy—Joys of Its Practice, Woes of Its Theory. By John L. Malm.......... 75
Chemistry of Salt Water Cement. By Harrison S. Taft.......... 76
THE WESTERN METALLURGICAL FIELD.......... 77
THE NON-FERROUS METAL MARKET.......... 78
THE IRON AND STEEL MARKET.......... 78
A Symposium of Papers on Undeveloped Elements.......... 79
Patent Suit Decision on Manufacture of Chill-Proof Beer.......... 80
Bureau of Standards Analyzed Brass Samples.......... 80
Bitumen and Electric Main Explosions.......... 80
Test of a Vacuum Pan. By E. W. Kerr.......... 81
Electric Iron Smelting at Hardanger in Norway. By John Harden.......... 82
Fine-Meshed Brass Gauze as a Substitute for Platinum in Electro-Analysis. By D. F. Calhane and T. C. Wheaton.......... 87
Concentration of Carnotite by Wet and Dry Methods.......... 89
The Power Problem in the Electrolytic Deposition of Metals. (Papers by L. Addicks, H. L. Longwell, and F. D. Newbury).......... 91
Notes.......... 94
The Present Status of the Wood Turpentine Industry. By E. H. French and J. R. Withrow.......... 95
Mechanical Refrigeration—I. By H. J. MacIntire.......... 99
A New Filter Press. By Alfred Burger.......... 101
Progress in Russian Chemical Industry.......... 104
Extinguishing of Fires in Oils and Volatile Liquids. By Edw A. Barrier.......... 105
Nitrates by Electrolysis of Peat.......... 107
Ductile Tungsten Patent.......... 108
Kieselguhr Industry. By Percy A. Boeck.......... 109
Federal-State Controversy over Radium-Bearing Lands in Colorado and Utah.......... 115
Handling the Raw Materials at the Iron Blast Furnace. By J. E. Johnson, Jr.......... 117
Electrochemical Progress in Norway in 1913.......... 124
High-Temperature Resistivity of Refractories a New Method of Measuring, with Results for Alundum. By Edwin F. Northrup.......... 125
Dry Chloridization of Ores. By John L. Malm.......... 128
Notes on Chemistry and Metallurgy in Great Britain.......... 130
Presentation of the Perkin Medal to John W. Hyatt.......... 131
SYNOPSIS OF RECENT CHEMICAL AND METALLURGICAL LITERATURE.......... 137
RECENT CHEMICAL AND METALLURGICAL PATENTS.......... 139
The Parral Tank System in the Leaching of Copper Ores.......... 141
PERSONAL.......... 141
DIGEST OF ELECTROCHEMICAL U. S. PATENTS.......... 142
BOOK REVIEWS.......... 142

## Aesop at Niagara Falls

A Sentimental Eagle and a Greedy Tiger lived on the bank of a great river, full of fish, and on the other side a Wise Beaver gnawed wood and dwelt at peace with his neighbors for a long time. One day, however, the Eagle and the Beaver disputed over the fish they caught, but at last agreed that for a time each should take a certain amount of fish from the river and so there was peace again.

The Tiger who hitherto had contented himself with other food, seeing that the Eagle was not taking all the fish which were his due, said:

"Behold, I also would eat fish."

Thus there arose a fierce fight between the Eagle and the Tiger; but the Beaver gnawed wood and said nothing.

After a time the Beaver said to himself:

"My foolish neighbors are busy fighting about the fish of which there is abundance in the river for all. My agreement with the Eagle is at an end, why should I not help myself?"

Whereupon, while the Sentimental Eagle and the Greedy Tiger fought, the Wise Beaver fell to catching all the fish he wanted.

*The crown of the wise is their riches:*
*but the foolishness of fools is folly.*

## Keeping Posted

Another chapter has been written on the subject of volatilizing metals as chlorides, which of itself might not excite special comment were it not for the fact that it is almost identical with a similar chapter written ten years ago. There is no thought of charging plagiarism on the part of the second engineer, for in these days of wide publicity in technical matters it would be absurdly foolish to present another man's work as one's own, even after the lapse of a decade. The wonder is that the later investigator carried his work so far without making a search in the literature to see whether his ideas had been anticipated.

About fifteen years ago Messrs. Pohle and Croasdale observed the volatility of metallic chlorides, and as the result of laboratory experiments were encouraged to try the process on a larger scale. Within the next few years they erected a plant, tested many ores, acquired a vast amount of experience and accumulated many data. In 1903 Mr. Croasdale published an article on the subject, and presumably the metallurgical world was properly advised of the status of volatilization as a process for treating ores. Considering the time and money spent in experimentation, the results published by Mr. Croasdale represented the extent of our knowledge on the subject at that time.

Last year Mr. Ben Howe announced from Australia that he had discovered a new process which was going to be of great advantage in the treatment of ores that were refractory to known processes. His work resembled that of Pohle and Croasdale in almost every respect. The apparatus employed for volatilization and condensation, the degree of success attained and the cause for ultimate failure were similar to those of the earlier investigators. And finally, Mr. Howe left the process exactly where American metallurgists had left it ten years before, having spent a great amount of money in duplicating their work, and failing to condense or collect his products, just as they had.

The Australian work was an economic waste of time and money because it demonstrated only known facts.

The moral is plain: before a metallurgist pursues too far an idea that is new to him, let him consult the records which it is one of the functions of a technical journal to preserve. A literary research should precede elaborate experiment. If Mr. Howe had known of Croasdale's work, he might have been discouraged from trying the process or would have tried to improve on it. Had he elected the latter procedure he would have had an excellent starting point. It pays to keep posted.

## The Power Problem of Electrochemistry

The power cost is usually a very considerable item in the cost sheet of electrochemical processes—so much so that this consideration has influenced to a large extent the geographical location of electrochemical industries. The hydro-electrochemical plants of Niagara Falls and Norway are typical examples. But it would be wholly wrong to conclude that electrochemistry must rely on water-power. Water, steam, gas, and even oil, all have their possibilities, according to the requirements of the case and the location. For the case of a large electrolytic copper refinery the subject is admirably treated in the papers of Messrs. Addicks, Longwell and Newbury, reported elsewhere in this issue. But the power problem in electrochemistry is a much broader subject and it is for this reason that this broad general subject has been chosen for a symposium at the general meeting of the American Electrochemical Society, to be held in New York City from April 16 to 18. This should be an opportunity for a lively discussion.

## Steel Costs and Selling Prices

The more optimistic are now insistent that a new era has dawned in the sale of steel products. The selling and operating departments are actually to work in harmony. The sales department is expected to abandon its old policy of advancing prices by getting under them and instead to conduct its sales of products with reference to the cost of producing them. In the one case the general manager of sales consults the cost sheet furnished by the operating department. In the other case he consults the treasurer with reference to the possibility of floating more paper.

The operating man has always felt hurt that while he labors hard and incessantly to save a dime per ton in the cost of producing steel the sales agent carelessly tosses away a dollar to get an order away from a competitor who scarcely needs such incentive to get back at sales agent No. 1 on the next inquiry that comes into the market. Of course, the sales agent's excuse is that a dime saved by improved manufacturing methods is permanent, applying on an indefinite number of tons, whereas the cut price is applicable only to the definite tonnage under negotiation. In practice, however, sales contracts for steel have been virtually guaranteed against decline, and thus the effects of a single cut have often proved far-reaching.

A natural law which is unfortunate from the viewpoint of selling methods in the past is that as the employment of a manufacturing plant increases the unit cost of production decreases. If a plant can produce steel at a cost of $30 a ton when operating at 60 per cent of capacity, and at $29 a ton when operating at 70 per cent, then it requires little computation to show that if the 60 per cent product has been sold at $30 it is theoretically possible to sell another 10 per cent at only $23 a ton and yet have the cost of the entire product equal to the average selling price. If the 10 per cent can be sold at $25 instead of $23 there is apparently an added profit to the mill in making the sale. In a declining market the trick would not work, for the cut price sale would endanger the previous sales made at the higher price, but in an advancing market there is a strong incentive to ignore the advances until full operation is reached.

The greatest friction between the sales and operating departments has come in periods of slack operation, when the sales department cuts prices to "meet the market" and calls upon the operating department to reduce its costs, at the very time when it is wrestling with the impossible problem of preventing the cost from actually rising through the reduced rate of operation. In lighter vein some superintendents have been urging the formation of an "operating men's union" collectively to resist the demands of the sales department and hold it to the basis of the operating costs being shown by the plant at the time the price on a given order is to be quoted. Should such a union succeed, we might have the interesting market spectacle of prices advancing as mills run out of orders and declining as they approach full operation.

Seriously, however, there is need of greater co-operation between the sales organization and the operating organization, and we hope the tendency towards such greater co-operation will grow. If generally practiced it will necessarily inure to the benefit of all.

## Custom Cyanide Mills

A recent venture in running a concentrating-cyaniding mill on a custom basis, in a district producing a wide variety of ores in comparatively small lots, calls attention to difficulties that may be encountered under such conditions. From a mechanical point of view no serious obstacles appear, for the different departments of the mill, such as concentrating, agitating, thickening, leaching or filtering, can be designed to meet the extreme conditions that may arise. Thus the thickening capacity, for example, can be based on the requirements of the ore yielding the slime most difficult to handle; and so on through the other departments. At times this extreme capacity will not be needed, but it is available when required.

Considered from the chemical point of view, however, the difficulties begin to multiply. Unless an elaborate bedding system is provided, with a regular supply of different ores to make the bed, there will be no uniformity in the mill feed. A fifty-ton lot of sulphide ore full of acid or other cyanide may be followed by one requiring little or no protective alkali; and these in turn may be followed by two lots, one of which requires a two-pound cyanide solution while the other will yield its metal only to a five-pound solution. Some lots may require long periods of agitation, while from others the bulk of the precious metals may be dissolved before the agitator is reached. The slime from some ores may have a high settling rate, and thicken to a low-moisture content in decantation, whereas other slime may require filtration for economic treatment. All of these features make it difficult, if not impossible, to obtain uniform milling conditions.

The commercial side of the proposition also offers some obstacles. The schedule of rates must apply to all of the ores offered, whether they are desirable or otherwise; and a nice adjustment is required to have these rates high enough to protect the operator in handling the least desirable ores, and at the same time low enough to attract the ores that are easily treated and from which the most profit can be derived. If other competitive means of ore treatment are at hand, the rate question becomes more troublesome, for the most desirable ores may be diverted to competing buyers who can offer better rates. This will result in surfeiting our custom mill with the most refractory ores from which little profit is to be made.

The conditions described are probably extreme, but are none the less real. They call for the most painstaking preliminary examination before the mill is built, and the best engineering and business skill afterwards.

## The Government's Trust Program

Time has been good to the Washington administration in the matter of the great trust program. Not until now has it been brought squarely to face the duty of developing and enacting a program. Meanwhile the thought of the country has largely crystallized, the trusts, or the "malefactors of great wealth" or whoever they are, have become relatively tractable, and through the training practiced in the tariff and currency legislation the parliamentary body which our last Democratic president referred to as "having on his hands," the present executive could, if he were not far too discreet, refer to as having in his hands.

Viewed with reference to the turmoil and confusion which has raged about the "trust question" the dominant note of President Wilson's address to Congress is not the peace between government and business upon which the daily press has harped, for that we had a right to expect; it is that the problem is to be attacked, not from the viewpoint of history, of what has occurred, of how the so-called "trusts" were put together, but from the viewpoint of what exists, what is private monopoly and what is not, and what is the conduct of great business organizations. It is being more and more frequently said nowadays that the Sherman law is better understood, is almost perfectly understood, but no understanding of that law can prevent the courts, in applying it in specific instances, to look largely to the method of formation of a "trust" thus tending to belittle the cogency of its present position and prospects. The talk at one time ran largely to the question whether an egg could be unscrambled, though some apparently wanted to end the uncertainty by eating it up. President Wilson's message does not run along such lines; it is eminently more practical in directing attention to conserving that which is to-day good, and destroying only that which is to-day bad.

The saneness and reasonableness of the administration's position may possibly be brought out well by the use of a little imagination. Let us conceive a man who can study things only by their genesis and see what a picture he might draw. In the decade of the nineties industry was full of secret agreements, "gentlemen's" agreements, associations, pools, all occasionally successful and all more or less unsuccessful at one time or another. Then came the promoter with Wall Street for the flotation of the securities he would create by buying out competitors, scrambling them, so to speak, and thus conducting the greatest of all conspiracies in restraint of trade, and obviously under the ban of the Sherman law, for years ago the court decided, in a Standard Oil case, that admitting that the separate entities brought together under a holding company had not previously been competitive, yet the formation of the holding company made the control more efficient and more easily administered, and was therefore illegal, even though there had been no competition which could directly be killed. A most lurid picture of what occurred years ago might easily have been drawn, and the viewpoint established of taking the genesis, not the present position and conduct of "big business" as the basis from which the trust problem should be attacked.

The president's message is not about a trust problem, but about a monopoly problem. It refers to what exists, and if it represents, as claimed, the crystallization of public sentiment, then the dissolution suits now in progress under the Sherman law have been an anachronism for some time past.

There lies no menace in the fact that many men will question the new freedom which the administration's program is claimed to promise, on the ground that there is no particular lack of freedom at present. Let the work be prosecuted to a finish. Those who criticise on the ground that there is little good for it to do can hardly at the same time insist that it will do harm. All admit that the removal of uncertainty is of prime importance, and that is clearly promised.

# Readers' Views and Comments

## Relative Thermal Conductivity of Silica and Clay Brick

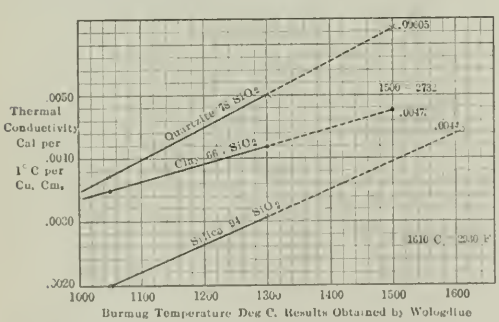
*To the Editor of Metallurgical & Chemical Engineering:*

Sir:—Reference has been made in The Metallurgical and Chemical Engineering and other publications during the past year to the heat conducting power of silica brick as compared to clay brick. In practically all cases it has been stated that silica bricks are less perfect conductors than clay bricks.

In the majority of cases this comparison has apparently been taken unquestioned from tests made by Wologdine and published in *Revue de Metallurgie*, June, 1909, and abstracted in Metallurgical and Chemical Engineering of September, 1909. In this paper the following comparison appears:

| Material | Approx. Analysis | Burning Temp., Deg. C. | Conductivity Cal. per 1° C. Diff. per Cu. Cm. |
|---|---|---|---|
| Clay brick .... | 78% $SiO_2$ 18$Al_2O_3$ | 1050 | .0037 |
| | 3.3$Fe_2O_3$.5 CaO | 1300 | .0050 |
| Clay brick .... | 66% $SiO_2$ 29$Al_2O_3$ | 1050 | .0035 |
| | 4 $Fe_2O_3$ .5 CaO | 1300 | .0042 |
| Silica brick ... | 94% $SiO_2$ 1% $Al_2O_3$ | 1050 | .0020 |
| | 2% $Fe_2O_3$.2% CaO | 1300 | .0031 |

These results are shown in the accompanying figure and the curves have been extended to the usual burning temperatures of the three materials. It will be observed that the conductivity of the silica brick burned at about 1600° C. is greater than that for clay as obtained by Wologdine, though somewhat less than the clay results at the usual burning temperature.



THERMAL CONDUCTIVITY OF CLAY BRICK AND SILICA BRICK AS FUNCTION OF BURNING TEMPERATURE

These results in themselves appear somewhat discordant, as it would be expected that the conductivity would vary at least in some regular way with the silica content.

While questioned, these figures are used by Havard in "Refractories and Furnaces" and by Hering in "Flow of Heat Through Bodies" in Metallurgical and Chemical Engineering, December, 1911. In numerous other places these tests appear to have formed the basis for a comparison of the value of these two materials either as heat conductors or as heat insulators. (Compare Randolph "The Conduction of Heat," *General Electric Review*, 1913; Tone "Carborundum Refractories," Metallurgical and Chemical Engineering, October, 1913.)

No doubt these data are correct comparatively for the materials tested, but the results show that the conductivity increases with the temperature of burn and commercial silica brick are burned at a higher temperature than 1300° and at a temperature from 125° to 225° higher than that used for clay brick. Hence, while the results given may be correct for the materials tested, yet they are useless for the comparison of commercial American refractories.

Experience with the use of silica brick as compared with either clay or quartzite brick in by-product coke ovens, gas retorts, checker chambers and many other places has shown that silica bricks are appreciably better conductors than the other two materials. One set of published data shows this. FitzGerald in "Experiments in Heat Insulation" (Metallurgical and Chemical Engineering, May, 1912) shows that 550 watts will maintain a temperature of 660° C. within a small test furnace built of clay brick, while 730 watts are required when silica brick are used.

A carefully conducted series of tests which would give a fair comparison between the refractories in regular use in America would be of value. It is possible that some such data may be available in the files of some of the refractory manufacturers which could be published and would be of value to users of these materials.

S. M. Marshall.

Johnstown, Pa.

## The Induction Furnace for Steel Melting and Refining

*To the Editor of Metallurgical & Chemical Engineering:*

Sir:—In your issue of October, 1913, some "Induction Furnace Notes" were given by Mr. Joh. Härdén. In these notes he stated the efficiency of a 2-ton furnace to be 63.8 per cent. In your December issue, however, he corrected this to be 67.1 per cent, assuming that in the first calculation he had made a mistake by using 636 instead of 606 units as the average consumption of electric energy during a run of 606 hours. On the left side of page 561 the time is, however, stated to be 606 hours and the amount of average energy used during said 606 hours to be 636 units. These values appear to be right and Mr. Härdén has probably got the figures mixed up in some way in his latter notes.

The efficiency is more likely to be only 63.8 per cent for a 2-ton furnace as the total efficiency of the 10-ton induction furnaces at the Krupp works is not more than 72 per cent, according to the statement in an advertisement on page 48 of the issue of January, 1913, of your paper. The difference in efficiency of a 2-ton and a 10-ton furnace should certainly be more than some 5 per cent, and this makes it probable that the lower value is the right one for the 2-ton unit. It would be interesting if Mr. Härdén would kindly explain more clearly why the efficiency is not 63.8 per cent as originally was stated.

The opinions about the merits of the induction furnace seem to be rather diverging among metallurgical engineers. In the issue of your journal of November, 1911, Mr. Joh. Härdén makes the statement that "it is well known that very little refining as regards sulphur and phosphorus can be effected in the induction furnace . . . " and proceeds to give some very good reasons for the alleged deficiency of the induction furnace in this respect. This statement is quite interesting as it emanates from a metallurgical engineer of high standing and closely associated with the induction furnace interests in Great Britain.

Contrary to said opinion are, however, some remarks by Mr. C. H. vom Baur in the January number of your journal for 1912, stating that he witnessed a 10-ton induction furnace refining basic Bessemer metal with phosphorus 0.08 and sulphur 0.09, getting $P$ and $S$ down to 0.008 and sometimes to traces and at the same time achieving a high degree of deoxidation.

There is entirely too much discrepancy between the two statements and this fact is certainly worth a careful consideration when deciding whether to install an induction furnace or a modern arc furnace.

In your issue of November, 1911, page 573, Mr. T. D. Robertson also states that the induction furnaces are difficult to use for refining purposes.

The induction furnaces admittedly possess some beautiful features but also have too many practical drawbacks to become ever general favorites or even to enable them to hold the place they have been occupying in the electrometallurgical industry. It would greatly benefit the development of the electric refining methods if an unprejudiced discussion could be started regarding the real and imaginary merits of all the different systems of electric furnaces now offered to the trade.

IVAR RENNERFELT.

Stockholm, Sweden.

---

## Hydrometallurgy—Joys of Its Practice, Woes of Its Theory

*To the Editor of Metallurgical and Chemical Engineering*:

Sir:—In reply to Mr. Bleecker's communication in your January issue, I will endeavor to establish my former statement that he is ignorant of the subject of dry chlorination. I shall do this impersonally, and mainly because Mr. Bleecker represents in this instance a type of engineer who presumes to pass opinion on matters of which he has little or no knowledge. Ofttimes, through failure of capital to recognize this kind of incompetency, the development of schemes is either undertaken without warrant or unduly delayed. The opinion of this type of engineer is a menace to any industry, whether he be for or against any particular proposal. The fact very often overlooked is that the absorption of knowledge in any one branch of a profession does not of itself qualify one to pass upon matters in every other branch.

Sour grapes? No! Dry chlorination has suffered from over-indorsement. Some of the most favorable indorsements have been based on conclusions equally as absurd as those assumed by Mr. Bleecker against it. I specifically object to incorrect or unwarranted assumptions, whether they be for or against dry chlorination or any other scheme.

A sub-type of engineer equally as dangerous is he who tries to cover his ignorance by shrug of shoulder or a silly smile. In such a case ignorance is accompanied by cowardice.

It was with no hope of convincing the agnostics or the advocates of other methods of ore treatment that dry chlorination will solve the complex ore problem that I threw down the challenge, but rather to bring out into the open if possible those who have selected a dark alley in which to waylay their victim. Certainly a revised code of ethics is needed in our profession, or a better understanding on the part of a few of the code now existing.

Mr. Bleecker excuses his ignorance on the ground that his knowledge was derived from published articles. This will not stand in view of the fact that on June 28, 1911, Mr. Bleecker was invited by me to accompany a party of engineers on the following day to Georgetown to inspect the plant under construction, receive a detailed statement of the proposed *modus operandi*, and go the limit of honest criticism.

Of the articles referred to by Mr. Bleecker, only that of Mr. Wolf was published with my knowledge, and the statements are correct as far as they go. A more detailed statement at that time was deemed unwise on account of the status of patent applications. The "incorrectness and absurdity" mentioned by Mr. Bleecker result solely from the unwarranted assumptions which he makes in connection with the published statements.

For convenience and brevity in making this reply, I have numbered the paragraphs of Mr. Bleecker's communication from 1 to 39 inclusive, and will refer to them by number. Such other items as I consider worthy of attention, and which are not touched on here, are covered in my article on dry chlorination elsewhere in this issue.

14. Certainly Mr. Bleecker's acknowledgments that the cycle of reactions is complete, the chemistry perfect, and the substitution process faultless are facts in favor of the process. Unless these initial conditions existed it would be folly to propose the scheme.

17. Apparently Mr. Bleecker has never made a test for extraction by dry chlorination. I have yet to find a sulphide ore which would not yield its values to any extent desired by the method referred to. As for the handling of chlorine gas, Mr. Bleecker need go no farther than Niagara Falls to enlighten himself on this subject. Referring to materials of construction, there is no need for unlimited choice of such materials for tanks, agitators, and filter presses. Impregnated wood answers every requirement, and asbestos filter cloths are equally as serviceable for filtering the solutions occurring in this process as canvas is in the filtration of non-corrosive solutions.

25-26-27. I wish to confirm Mr. Wolf's statement as to the recovery of from 14.2 to 14.4 pounds of zinc per horsepower-day. I have, however, been unable to ascertain where Mr. Bleecker gets the figure of 3.5 for voltage, as used in his calculations. This voltage was provided to take care of both internal and external resistance, and might justly have been mentioned as the voltage employed. In other words, a total voltage of 75 on a series of 20 cells would be a factor in determining the *cost of electrolysis*, but certainly should not be involved in determining *cell efficiency* as Mr. Bleecker has applied it. The voltage required for internal resistance of each cell did average 3.1. Therefore the theoretical quantity of zinc deposited per horsepower-day at 3.1 volts is

$$\frac{746 \times 24 \times 1.2}{3.1 \times 453.5} = 15.3 \text{ lb.}$$

The ampere-hour efficiency of the cells is $\frac{14.3}{15.3} =$ 93.4%, which is not unusual in other forms of cells. The watt-hour efficiency is 66.4%, thus

$$\frac{746 \times 24 \times 1.2}{2.2 \times 453.5} = 21.53 \qquad \frac{14.3}{21.53} = 66.4\%$$

Can Mr. Bleecker now figure how much "heat" we derive from "calcium sulphate"?

31. Mr. Bleecker is correct. The entire cost of grinding, chloridizing, "bottling," etc., can be done for $1.86 per ton, including the cost of electric power for these operations.

34. Silica, lime, iron, magnesia or arsenic are not factors. The chlorides of metals not sought are employed to chloridize the metals which it is desired to recover from the ore.

37. I have no knowledge of calcium sulphate causing any difficulty. Its presence in solutions has been observed only from slight deposits in first-stage evaporators, but not in the fused zinc chloride.

Mr. Skinner's communication certainly favors the further development of dry chlorination, if for no other purpose than to handle successfully the finely disseminated ores, in the treatment of which there is no competition. That is just the application for which the process is urged as a starter, although I am convinced of its broader application.

The advocates of mechanical concentration can find little solace in the results reported in your January issue on the concentration of the complex sulphide ores at the Mary Murphy mine. I understand that the treatment of this ore is conducted under the most favorable conditions of expert direction and up-to-date appliances, and yet the results are not all that could be desired. It is just such instances which have discouraged even an attempt to apply mechanical concentration to complex ores. It is about time mechanical concentration was passing through a period of refinement; and even if we have competent metallurgists to usher in this period of improved mechanical methods, we can be equally certain that hydrometallurgists will respond to the demands of their profession.

Dry chlorination has been recognized far more favorably by Mr. Skinner than I had expected, but even to win this favor it has not modified its early claims, although it has been willing, for sake of argument, to have its merits determined by using a factor of 2 on its estimated cost of operation. I can understand how those who are actively engaged in mechanical concentration do not find time to consider seriously the developments in other lines. Many have gone to sleep at the switch from sheer exhaustion in meeting the pressing demands of their own work; others find time to make only superficial examination of the claims of other processes, and consequently fall into error.

Denver, Colo. John L. Malm.

## Chemistry of Salt Water Cement

*To the Editor of Metallurgical and Chemical Engineering:*

Sir:—To my article on the "Chemistry of Salt Water Cement," published on pages 26 to 30 of your January issue, I wish to make a few additions so as to make them a part and parcel of my original article.

After the fourth line of the right column of page 27, the following insertion should be made:

"It has been authoritatively stated that the Italians were the first to make use of pozzolana, trass, or tuff—together with the admixture of a larger proportion of cement—for making concrete that was to stand in sea water more impermeable and more resistant; both mechanically and chemically. Since then the practice of thus treating concrete has become very popular in Germany and Holland. In Italy, where pozzolana is so abundant, the practice of using only Portland cement, sand, gravel or stone for sea water concrete was looked upon with suspicion. Though the cost of cement is high in Italy, this feeling of doubt is based upon the dangers of decomposition of cement in sea water unless pozzolana was used.

"The successful use of pozzolana by the Italians and the French is no doubt accounted for by the exceptionally good quality of Mediterranean lime. While lime concrete has been used with marked success in the dock work of England, in her sea structures, that is, where the concrete is exposed to the full force of the waves and pounding action of the seas, it had not proven to be a success.

"The excellent results obtained from using pozzolana concrete in sea water structures are shown by the mole of Nero, at Porto d'Anzio, or of Hadrian, near Bari; structures still in existence, though built 17 centuries ago.

"In explanation of the long life of these two structures, Prof. Luigi Luiggi, the noted Italian Engineer, has said: 'Pozzolana contained a large amount of free gelatinous silica ready to combine with the free lime that unfortunately was always present in Portland cement—even the best. Thus, when Pozzolana was added in mixing Portland cement concrete, there was always present a large excess of silica over this free lime, and the result was a kind of acid mixture, instead of the basic mixture that was the consequence of the free lime in cement. This acid concrete resisted better the decomposition of the sulphate of magnesia of sea water, which acted on the basic mortar of concrete—decomposing it and causing free or inert magnesia to be found and sulphate of lime, which had a tendency to crystallize and expand; the consequence of the expansion being disintegration of the concrete."

The beginning of the fourth paragraph of the right-hand column of page 27 should read as follows:

"As considerable stress has been laid above on the German method of manufacturing cement, and on the Italian use of pozzolana, for sea water concrete * * *"

After the 29th line of the right-hand column of page 29, the following paragraphs should be inserted:

"The usual Italian practice for mass concrete laid in harbor work is:

100 to 200 Kilograms of Portland cement,
1 Part ordinary lime; by volume,
2 Parts Pozzolana,
3 Parts gravel or ballast,
for every cubic meter of concrete.

"In discussing this mixture, Prof. Luigi Luiggi says that such concrete will keep plastic for 6 to 8 hours and allow plenty of time for it to be properly pressed into each and every part of the form without tamping. In other words, the concrete is forced into place by hydrostatic pressure; resulting in a more dense concrete than when a quick setting mixture was used. He states concrete made of the above mixture will not suffer any damage after 12 to 20 hours, even from the wash of the waves and that it gives almost as good results as ordinary concrete laid in the opening for block work, etc.

"A mixture commonly used in Italy for premoulded piles, hollow concrete blocks and floating caissons is:

| | Pile work subject to blows | Floating caissons |
|---|---|---|
| Portland cement | 500 to 600 kg. | 350 to 400 kg |
| Pozzolana | 150 to 200 kg. | 100 to 150 kg |
| Sand | 40 cu. m. | .40 cu. m. |
| Gravel or stone 1 in diameter | 80 cu. m. | .80 cu. m |

For 1.1 cu. meter of concrete.

For 1.1 cu. meter of concrete.

"The excess of cement in the pile mixture in comparison with the ordinary mixture quoted above is on account of the heavy blows the piles are subjected to in driving. In the floating caissons mixture the excess of cement is so very small in relation to cost of the reinforcement, forms, labor, etc., as to be negligible; especially in consideration of the great expense necessary to repair an ordinary structure disintegrated under the heavy lateral blows or of sea action. Or as stated above, the increased resistance to sea action more than compensates for the additional amount of cement; especially for that part above low water.

"While a number of experiments made in Scotland show that a 1-2-4 concrete with a $2\frac{1}{2}$ size stone makes the best kind of concrete for mass sea work, at

Southampton it has been found that far better results are obtained in mass concrete deposited under water by using a stone that will pass through a 1-inch ring.

"(NOTE.—The source of the information upon the Scotland experiments seems to refer to premoulded block work not mass concrete deposited under water as per Southampton reference.)

"A method of improving the quality of cement very often practiced in England in connection with the most important concrete structures standing in sea water is that of 'Aerating of the Cement.' The cement is received on the works in bulk form, put into special bins and then turned over a predetermined number of times at regular intervals before being used. It is said that such a treatment of the cement not only increases its resistant power against sea water, but that the increase in bulk more than compensates for the labor cost of the turning."

Seattle, Washington. HARRISON S. TAFT.

## The Western Metallurgical Field

### Flotation of Lead and Copper Ores

As previously mentioned in this column, many companies over the country are investigating the possibility of treating sulphide ores by oil flotation. Where concentrating mills already are established, the line of investigation has been to test the possibilities of flotation for some of the low-grade mill products, such as middlings or tailings. Some of the lead mining companies in southeast Missouri, in the Flat River district, have recently decided to begin treating slime tailings from the mills by flotation. No statement is given as to the process to be used, except that it will be oil flotation. The mill tailings will have to be thickened from about 50:1 to 4:1 before adding the oil in the flotation machines.

The Consolidated Arizona Smelting Co., of Humboldt, Ariz., also is to adopt flotation for the treatment of a part of its mill product. The present mill contains jigs, tables and vanners. According to Mr. G. M. Colvocoresses, who outlined the proposed plan at a recent meeting of the New York section of the Mining and Metallurgical Society of America, the remodeled plant will continue to make jig and table concentrates. The tailings from these machines will be combined with the fine material from classifiers, and reclassified, the coarse portion being reground to 60-mesh in a Hardinge mill. The resulting fine pulp will be thickened in a Dorr thickener, and treated by flotation. The thickening is considered an important point, as the pulp should go to the flotation plant at a consistency of two or two and a half parts water to one of solids. The exact degree to which grinding will have to be carried is not definitely determined, but practically all the mineral is separated from the gangue at 60-mesh. The problem of dewatering the flotation concentrate is one still confronting the management; further, the roasting of very fine concentrate is likely to introduce greater loss in flue dust.

The recovery by present gravity methods of concentration at Humboldt is given as not more than 65 or 70 per cent. Tests from the flotation plant indicate recoveries ranging from 83 to 96 per cent., but it is not anticipated that a recovery of more than 85 to 90 per cent. will be made on the material treated. The exact kind and amount of oil and acid that will be required are not yet determined, and will be subject to experiment after the plant is in operation. The cost for oil and acid is expected to be from 10 to 20 cents per ton treated.

### Minerals Separation Company's Attitude

At the same meeting of the New York section of the Mining and Metallurgical Society of America, mentioned above, Mr. J. Parke Channing gave voice to some thoughts on the methods of exploiting flotation adopted by the Minerals Separation Company. Many of the same sentiments have been expressed throughout the West, and the feeling prevails that this company makes the terms for adopting its process needlessly onerous. As Mr. Channing has expressed the idea in forcible manner, we quote the following from his remarks, as published in the Society's *Bulletin No. 67*:

"Unfortunately, the Minerals Separation Company has firmly rooted ideas as to the exact manner in which the process shall be applied, which ideas have met with very little favor among American engineers. What the company would like to do is to take your ore, experiment with it, and if it concludes that the ore can be treated, it will build your mill and treat the ore. Now few engineers feel like leaving the erection of a mill treating 3,000 to 10,000 tons a day to the mercy of English engineers who are used to handling small tonnages. As a result, the company has not been able to induce American mines to coöperate with it.

"A second drawback is that the company desires to treat the whole of a given ore by flotation. The process gives a very high recovery of rich mineral, but in such physical condition that it is not easily amenable to the smelting operations which have to follow. This is the method it proposed to the Caucasus Copper Co., of Russia. There, by the present water concentration, they get a 70 per cent. extraction; by flotation experiments they got 95 per cent. The Minerals Separation Company would agree to permit the copper company to use the process only if applied to the entire ore. The copper company wisely refused to do this, realizing that it would be impossible to treat such fine concentrate in McDougall roasters and reverberatory furnaces.

"The Inspiration mine, I understand, agrees to pay a certain royalty based upon the tons of material actually treated by the process. The construction of the mill is left entirely to the engineers of the Inspiration, and in their case the treatment is to be preceded by water concentration. After a portion of the chalcocite is extracted the remainder is treated by flotation. At Miami we have as yet made no experiments with the flotation process, and I do not know exactly how it will work out on our ore. Any flotation system works better on ores containing pyrite or chalcopyrite than on ores containing chalcocite. At the Inspiration, however, when the middlings were crushed to 100-mesh, they made a very satisfactory saving on the chalcocite."

### Smelting in Nevada

With the operation of copper converters which were recently installed at the smelter of the Mason Valley Company, the plant is now completely equipped for the production of blister copper. Converting operations began about the first of this year, and brought to an end the shipments of matte which have been going to the Garfield smelter in Utah since Mason Valley first began to smelt. The new department has ample capacity to handle the matte now produced from both company and custom ores.

Progress is being made by the new Consolidated Coppermines Co., which consolidated a number of mines in the Ely district, including the Giroux. Churn drills are steadily at work prospecting the ground now under this company's control, and a considerable area of new ground has been found ore-bearing. Financial arrangements were recently completed for the erection of a smelting works. A bond issue has been authorized to the extent of $3,500,000 at 7 per cent. interest, payable semi-annually. The location of the new smelter is not definitely settled, although a corps of engineers has surveyed a site at Warm Springs which is known to be favored by the management. In all probability the matter will not be settled until the company knows what attitude the surrounding land owners will take in regard to smelter smoke. The company has asked these people to waive future damage from smelter smoke, and is engaged in now getting their signatures to such an agreement.

### Purchase of Colorado Gold-Dredging Industry

The Tonopah Mining Co., engaged in mining at Tonopah, Nevada, has recently purchased the property and equipment of the gold-dredging companies operating in the vicinity of Breckenridge, Colorado. The transaction includes the dredges of the Reliance Gold Dredging Co., and the Colorado Dredging Co., the machine shops of the Gold Pan, and several thousand acres of land. The Tonopah company has been looking for a new mining property for some time, and has finally made a new venture by embarking in dredge boats in a search for gold. The sale was one of the largest that has been made in Colorado for years, and is said to have involved a million dollars.

### Estimated Budget for Bureau of Mines

The estimate expense for conducting the work of the U. S. Bureau of Mines for the fiscal year ending June 30, 1915, has been approved by Secretary Lane of the department of the interior and forwarded to Congress. No action has been taken at the time of writing, but it is probable that the estimate will be allowed. The proposed division of the appropriation is as follows:

| | |
|---|---|
| General expenses of the bureau | $70,000 |
| Equipment of mine rescue cars and stations | 30,000 |
| Equipment of Pittsburgh testing plant | 10,000 |
| Investigating mine accidents | 347,000 |
| Testing fuels | 135,000 |
| Mineral mining investigations | 120,000 |
| Investigations of petroleum and natural gas | 30,000 |
| Inspection of mines in Alaska | 7,000 |
| Books and publications | 2,000 |
| Lands, leases, etc., for mine rescue cars | 1,000 |
| Total | $752,000 |

This budget provides for an increase over that of the current fiscal year of $90,000, represented by the items of $30,000 for equipment of rescue cars and stations, $10,000 for equipment for Pittsburgh testing plant, $30,000 for investigations in petroleum and natural gas, and a $20,000 increase in the former appropriation for mineral mining. It is understood that part of the appropriation for petroleum and natural gas will revert to mineral mining investigations, on account of the fact that part of the present appropriation for the latter purpose has already been diverted to the former.

As an instance of the need for funds to investigate petroleum and natural gas, the conditions existing in the Cushing field of Oklahoma are cited. The maximum yield of oil in that district has never been over 30,000 barrels per day, and the average value of daily production is probably less than $20,000. Nevertheless the waste of natural gas from drilling and producing wells in this district has been as high as 300,000,000 cubic feet per day, worth about $75,000 at domestic rates, or perhaps $20,000 per day to the producers. It is to study such conditions that the appropriation for oil and gas investigations is asked.

### Labor Situation in Michigan

The deportation of Mr. Moyer, president of the Western Federation of Miners, from Houghton, and his later indictment by a grand jury, are the principal features of the labor strike in Michigan. Federation officials were indicted for conspiracy to restrain laborers from going to work, for restraining imported laborers from working, and depriving laborers of their rights and property. Thirty-nine officials were named in one indictment.

## The Non-Ferrous Metal Market

During the last week in December the non-ferrous metal market showed more activity than had been in evidence for some time, and sales were large at slightly increased prices. But during the first week of the new year the activity disappeared and the markets experienced a general decline.

**Copper.**—Competitive selling has marked the activity in this market to such an extent that consumers have been inclined to hold off on account of the demoralization in prices. Prices for electrolytic have declined daily and the market for Lake is wholly nominal. The latest available quotations are 13.80 to 13.90 cents for electrolytic, with the market weak.

**Tin.**—Considerable business was transacted in the domestic market during the last of December, but with the decline in the London market in the first week of January domestic buying ceased and a low price was established. January tin was quoted at 36¾ cents.

**Lead.**—The leading producer has fixed prices, which showed a slight advance during the holidays, but again declined in January. Independent producers were at first inclined to let the A. S. & R. Co. take the business, but later offered metal liberally. The last quotations are 4.10 cents New York, and about 4 cents St. Louis.

**Spelter.**—This market has been dull with little fluctuation in prices. Sales are not heavy and consumers are buying only for immediate needs. New York quotations are 5.20 to 5.25 cents, with St. Louis at 5.05 to 5.10 cents.

**Other Metals.**—The aluminium market shows a slight improvement, with quotations at 18½ to 19 cents. Antimony is quiet, with fair sales for immediate delivery. Various brands are quoted at from 6 to 7.30 cents. A steady business prevails in quicksilver, with New York prices $38 to $39 per flask of 75 lb., and $38.50 at San Francisco.

## The Iron and Steel Market

The slight improvement in the general tone of the iron and steel market, referred to in last report as occurring in the closing days of December, has developed into a definite and clearly market improvement in the past month. There has as yet been nothing like the spectacular revival which has often characterized the industry's recovery from depression, but there has been a decided improvement in bookings and production, and a slight stiffening in prices, amounting in the case of a few products to definite advances.

Many of the steel mills closed entirely over the holidays, and some of the attendant blast furnaces, to the number of more than a score, were banked. Resumptions occurred at various times in the first fortnight of January and at the close of the month the steel industry is operating at fully 60 per cent of its maximum capacity, while the actual production in the month was between 50 and 55 per cent of capacity. These percentages compare with operation at the rate of about 50 per cent in the fore part of December, and production for the month as a whole little if any over 40 per cent of capacity.

There has been very little long term contract tonnage booked, the mills instead looking for definite orders, with specifications attached. It is possible that the refusal of mills to protect buyers by giving them the usual option or "jug handled" contracts has been largely responsible for the increase in actual specifications, particularly since the lowest prices have been named on definite orders rather than on contracts. At the lowest—the general level being now discernibly above the minimum—prices did not reach the low average of two years ago by about $2 a ton, and this fact is variously explained. The mills have certainly been under as much competitive strain lately as at the former minimum, perhaps under more. Increased cost of production, through the general wage advance of February 1, 1913, is cited as one cause, while another seems to be that the mills have a different philosophy now.

With the low tariff in effect there is less promise than formerly of relatively high prices for any period in the future, and there is therefore less inducement to start a buying movement by naming very low prices and then expecting a prolonged advance in prices to produce a fair average. In many cases it is known that the sales offices are working more closely in harmony with the operating departments and paying more attention to the cost sheets.

### Pig Iron

Buying of pig iron in January was fairly heavy, and was marked by the first definite buying for forward delivery since last midsummer. For months buyers had covered only for immediate requirements, but late in December some of the larger buyers began to adopt the idea that if prices were not definitely advancing, they at least stood much more chance of averaging higher than of averaging lower, during the first six or nine months of the year. Buyers who have covered, however, have not taken tonnages equal to their full normal requirements. Under stress of competition produced by important inquiries prices declined in many markets early in January, but at the close of the month the advancing tendency seems to predominate, and at Buffalo there has been a clear cut advance of 50 cents a ton.

The manufacturers of Bessemer and basic pig iron in the valleys are as a rule holding their output at higher prices than are openly quoted as a market. Quotations stand as follows: No. 2 foundry, f.o.b. Birmingham, $10.50 to $10.75; No. 2X foundry, delivered Philadelphia, $14.75 to $15; No. 2 foundry, f.o.b. furnace, Buffalo, $12.50 to $13; No. 2 foundry, delivered Cleveland, $13.25; No. 2 foundry, f.o.b. Chicago furnace, $13.50 to $14; at valley furnaces (90 cents higher delivered Pittsburgh), Bessemer, $14; basic, $12.50; No. 2 foundry, $13; malleable, $12.75; gray forge, $12.50. Late in December the Carnegie Steel Company appeared as a seller of ferromanganese, which it had previously made only for its own use, and it closed several contracts with consumers for their requirements during the first six months of the year, on the basis of a price to be named each month, the price to be about $2 below the price of imported material. The price for January was fixed at $47, delivered to points near Pittsburgh. In a short time the English and German makers reduced their price from $47 to $45, f.o.b. Baltimore.

### Steel

Late in December a slight further weakening occurred in unfinished steel, chiefly with respect to open-hearth sheet bars, which were offered down to $20, maker's mill, Pittsburgh or Youngstown, the quotation on Bessemer bars remaining at $21, while billets were not generally quoted below $20. After the 15th of the month the Carnegie Steel Company announced its withdrawal from the market as a seller of billets or sheet bars and the tone of the market began to improve, until it became difficult to buy open-hearth bars at the old price.

No clear cut advance, however, has occurred in unfinished steel, except that rods have been advanced from $25 to $26.

### Finished Steel

The trend in unfinished steel prices has been in the upward direction, though there have been few definite advances. Bars, plates and shapes late in December could be done at 1.15 cents, on attractive tonnages for quick shipment, though the open quotation was 1.20 cents, and the concession is now practically withdrawn, except as to bars and plates in Chicago territory. During the last week in the old year and the first week in the new mills booked definite orders for wire nails at $1.50, and then firmed up to a $1.55 basis. Sheets were done freely on the basis of 1.80 cents, but early in January firmed up to 1.85 cents, and on January 22 the leading interest made the somewhat radical advance to a basis of 2 cents, a price which the independents will probably reach early in March.

In all cases the firming up in prices has been due to the receipt of heavier bookings in the form of actual specifications.

Prices named below are f.o.b. Pittsburgh, unless otherwise stated:

Rails, standard section, 1.25c. for Bessemer; 1.34c. for open-hearth, f.o.b. mill, except Colorado.

Plates, tank quality, 1.20c.

Shapes, 1.20c.

Steel bars, 1.20c., base.

Iron bars, 1.35c., Pittsburgh; 1.22½c., Philadelphia; 1.10c., Chicago.

Wire nails, $1.55 per keg, base; plain wire, 1.35c., base.

Sheets, blue annealed, 10 gage, 1.45c.; black, 28 gage. 1.90c. to 2c.; galvanized, 28 gage, 2.90c. to 3c.; tin mill black, 1.85c. to 1.95c.; painted corrugated, 28 gage, 2.10c. to 2.20c.; galvanized corrugated, 28 gage, 2.95c. to 3.05c.

Merchant steel pipe, ¾ to 3-in., 80 per cent. off list.

Steel boiler tubes, 3½ to 4½-in., 71 per cent. off list. (Revised from 69 per cent. on January 2d.)

Standard railroad spikes, Pittsburgh, 1.50c.; Chicago, 1.50c.

Structural rivets, 1.70c.; boiler rivets, 1.80c.

Cold rolled shafting, 64 per cent. off list.

## A Symposium of Papers on "Undeveloped Elements"

The next meeting of the New York section of the American Electrochemical Society will be held in the Chemists Club Building in the evening of Friday, February 6.

This meeting will be a joint meeting with the New York sections of the American Chemical Society and the Society of Chemical Industry.

The subject of the evening will be "Undeveloped Elements" and the program is as follows:

"Opening up the Field of Unused Elements." By Dr. Charles Baskerville.

"The Present Status of Cobalt." By Dr. H. T. Kalmus.

"The Present Status of Boron." By Dr. E. Weintraub.

"The Present Status of Tungsten." By Dr. R. W. Moore.

By "undeveloped elements" is meant those elements which are available as by-products or otherwise in excess of present demand. Some are dead, such as tellurium; some are comatose, such as selenium and cadmium; some are very limited in their applications, such as bromine.

Discussion will not be limited to the actual papers presented.

It is hoped that an interesting exhibit can be made of products relating to the subject.

## Patent Suit Decision on Manufacture of Chill-Proof Beer

A decision has just been rendered in the patent suit for the manufacture of chill-proof beer in the United States District Court of the Eastern District of New York. The plaintiffs were Max Wallerstein and Leo Wallerstein, suing the S. Liebmann's Sons Brewing Company for infringement of Leo Wallerstein's patents, 995,820 and 995,824.

The decision of the court, written by Judge Van Vechten Veeder, is in favor of the complainants, the patents in issue being held valid and infringed.

The following quotations from the decision seem to be of general interest to chemists:

"The development of the bottling industry brought about a change in the method of consumption of beer. Instead of being served from the keg, or at all events within a short time after leaving the brewery, it was shipped long distances and kept for considerable periods of time. When thus kept, even at ordinary temperatures, beer tends, from a lack of stability, to become hazy and cloudy, and to deposit a sediment. But in this country it is customary to drink bottled beer very cold. This chilling causes brilliant beers or sparkling ales to lose their brilliancy and to become hazy and cloudy. It was soon found that under conditions of long shipment and storage the most carefully brewed beer developed micro-organic growths. To eliminate this brewers adopted the practice of pasteurization; that is, the beer in bottles was subjected to a temperature of from 140 deg. to 150 deg. F. for about half an hour. But while pasteurization prevented the growth of microorganisms, pasteurized beer was found to be particularly sensitive to cold and unstable. There remain in the beer after steaming certain substances of an albuminous nature, which, while invisible at the time of steaming because dissolved, are slowly affected by a number of causes and become less readily soluble, especially at low temperatures, finally causing haziness or sedimentation and thus rendering the beer unsightly and unpresentable.

"The production of stable and chill-proof beer was therefore a problem of vital importance to brewers. The evidence leaves no doubt of the reality of the problem or of the difficulty involved in its solution." . . . .

"The patents in suit produce chill-proof and stable beer by adding to the beer at the proper stage a minute quantity of a proteolytic enzym active in an acid medium. Proteolytic enzyms are divided into classes according to the medium in which they act, that is, whether acid, neutral or alkaline. The patents in suit refer to four proteolytic enzyms active in acid medium: pepsin, an animal enzym obtained from the stomach of pigs; papain, an enzym derived from the pawpaw; bromelin, a vegetable enzym derived from the pineapple, and malt peptase, derived from malt. Enzyms suitable for the purpose described are widely distributed in the vegetable and animal kingdoms, and are readily prepared in concentrated form by known methods.

"The procedure by which proteolytic enzyms active in an acid medium are employed for the purpose of chillproofing and stabilizing beer, is exceedingly simple, and is specifically set forth in the patents in suit: 'According to the present process, there is added to the beer at any suitable stage of the brewing, that is to say at any period subsequent to the cooling of the wort, and usually after the conclusion of the main fermentation, a proportion of proteolytic enzyms active in slightly acid media sufficient to modify the proteids contained in the beer in such manner that they will not be precipitated upon chilling subsequent to pasteurization, the beer being rendered chill-proof in the sense that it is capable of remaining brilliant even when kept upon ice for a considerable time. In practice it has been found advantageous in most cases to add the enzyms to the clarified beer shortly before bottling. During the pasteurization which follows the bottling, the enzyms become active, and those proteids which would cloud the beer when chilled are so modified by the proteolysis that the resulting beer will remain clear and brilliant, being no longer sensitive to cold.' " . . . .

"Since the evidence satisfies me beyond any reasonable doubt that the defendant's beer is made chill-proof and stable by the use of proteolytic enzyms active in acid medium, and that the infringement is a deliberate and flagrant appropriation of Wallerstein's disclosures, attention may be directed at once to the grounds upon which the validity of the patent is attacked.

"The defendant introduced much testimony to show that certain extracts have long been made by compounding pepsin with malt liquor, the latter serving as a carrier for the former. It may be said at the outset that the defendant's testimony with respect to these malt preparations is wholly unsatisfactory. The testimony of the defendant's witness Wyatt was so obviously unbelievable that its counsel stated upon the argument that it would not be relied upon." . . . .

"My conclusion is that the patents in issue are valid and infringed. The complainants may have the usual degree."

## Bitumen and Electric Main Explosions

The British Board of Trade has appointed a committee to investigate the explosions connected with electric mains laid in bitumen. The inquiry is the outcome of an explosion of gas at Hebburn-on-Tyne, several months ago, by which two houses were blown up and two persons were killed, and which was attributed to gas generated from the bitumen in the trough at a bend where a fault in a direct-current vulcanized-bitumen-insulated cable at a moist spot caused a short circuit and consequent destruction of about 6 ft. of cable and the bitumen in which it was laid.

The fault was very close to the house, the gas found its way through loosely constructed foundations into large air spaces under the ground floors, air was supplied by a ventilator inlet facing the fault, and, in some unascertained way the mixture became ignited, with the result stated.

Hitherto considerable divergence of opinion has existed as to the causes of joint-box and similar explosions, and on some occasions very elaborate theories have been advanced. In the case of an explosion in London several years ago certain experts attributed the ignition of the explosive gaseous mixture to the action of water on metallic sodium produced by the electrolysis of sodium salts derived from the surrounding soil; but in this instance the cable was not laid in bitumen and the hydro-carbon gases were said to have been derived from a neighboring gaspipe.

Bitumen is so extensively used both as filling for cable troughs and, when vulcanized, as a dielectric covering for cables that all who are concerned will regard an official inquiry with satisfaction.

## Bureau of Standards Analyzed Brass Samples

The Bureau of Standards, Washington, D. C., is prepared to issue a sheet brass of the following composition, approximately: Sn, 1; Pb, 1; Cu, 70.3; Zn, 27; Fe, 0.3; Ni, 0.5. The fee, payable in advance, is $3 per sample of about 150 grams weight.

# Test of a Vacuum Pan

BY E. W. KERR

The following data were obtained from a test of a vacuum pan in a Louisiana sugar house where white sugar is made direct from the cane. The pan tested was of the calandria type, known as the Stade express vacuum pan.

This type is shown diagrammatically in Figs. 39 and 40 on pages 349 and 350 of the July, 1911, number of METALLURGICAL AND CHEMICAL ENGINEERING. It should be stated, however, that the condenser of the pan tested was a dry condenser and differed materially from the illustration mentioned.

The object of the test was to secure data relative to heat transmission, also steam consumption. The test was, in fact, a history of one strike.

The syrup fed during the test was measured in large storage tanks which were carefully calibrated.

The density of the syrup fed and of the masse-cuite leaving was obtained by means of Brix spindles which had been carefully calibrated.

The weight of condensed steam leaving the pan was measured by means of a Venturi meter, the manometer of which was read every two minutes throughout the test.

The condensed steam was removed from the pan and pumped directly into the boilers by means of an automatic receiver pump.

The receiver being of liberal capacity, the flow of condensed steam from the pan was fairly steady and for this reason the meter readings should be fairly accurate.

The amount of water removed from the syrup in the form of vapor during the boiling process was calculated from the weight of syrup fed and the initial and final density.

One of the items difficult to obtain in determining a heat balance is that of the specific heat of the syrup, also that of the masse-cuite.

In arriving at this quantity it was assumed that the specific heat of the mixture of sugar and water was equal to the sum of the heat in the dry matter plus the heat of the water, degrees Brix, representing the per cent of solid matter.

It will be noticed that the purity of the product was 71.5 per cent, that is, of the total dry matter 71.5 per cent was sugar.

In the specific heat determination it was assumed that all of the solid matter was sugar, which may not be absolutely accurate, though it is probably very nearly so.

The specific heat of sugar was taken to be 0.301.

I hope the results of this test will be found interesting. So far as I know no data of this nature have been published.

The results of the test are given concisely in the table in the right-hand column of this page, together with a heat balance sheet, showing the amounts of heat entering and leaving and the heat lost in radiation and not accounted for.

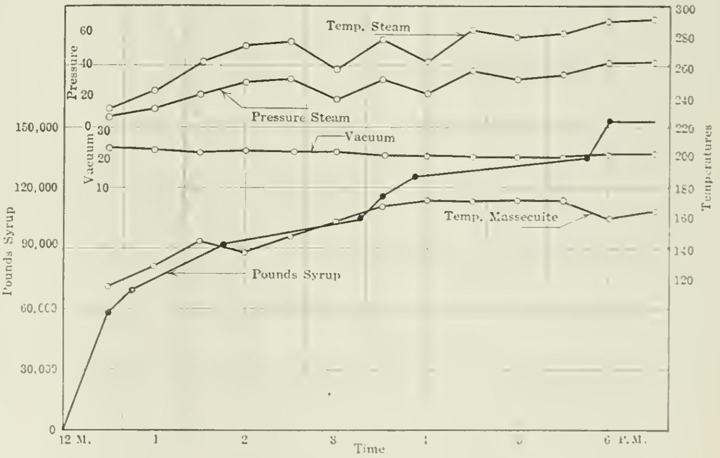
Louisiana State University and Audubon Sugar School.
Baton Rouge, La.

## Summary of Test

| | | |
|---|---|---|
| 1. | Type of pan | Calandria (Express) |
| 2. | Type of condenser | Counter current jet (Barometric) |
| | DIMENSIONS | |
| 3. | Heating surface, square feet | 750 |
| 4. | Diameter of pan, feet | 13 |
| | PRESSURES | |
| 5. | Pressure of steam to pan calandria, lbs. gage | 28.8 |
| 6. | Vacuum in vapor space, inches of mercury | 23.4 |
| | TEMPERATURES AND DENSITIES | |
| 7. | Temperature* of steam in calandria of pan | 272 |
| 8. | Temperature of steam, condensed | 270 |
| 9. | Temperature in vapor space | 143 |
| 10. | Temperature of entering syrup | 175 |
| 11. | Temperature of masse-cuite leaving | 156.7 |
| 12. | Temperature of injection water entering condenser | 64 |
| 13. | Temperature of injection water leaving condenser | 132 |
| 14. | Density of syrup entering, Brix | 49.4 |
| 15. | Density of masse-cuite leaving, Brix | 94.8 |
| 16. | Purity of syrup fed | 71.5 |
| | TOTAL QUANTITIES | |
| 17. | Duration of test (strike), hours | 6.05 |
| 18. | Volume of syrup fed, gallons | 15,387 |
| 19. | Weight of syrup fed, pounds | 152,932 |
| 20. | Per cent evaporation | 47.89 |
| 21. | Weight of water evaporated from syrup, pounds | 73,139 |
| 22. | Weight of steam condensed, pounds | 93,815 |
| 23. | Weight of cooling water to condenser, pounds | 1,100,010 |
| | HOURLY QUANTITIES | |
| 24. | Syrup fed, per hour, pounds | 25,278 |
| 25. | Water evaporated from syrup per hour, pounds | 12,089 |
| 26. | Steam supplied per hour, pounds | 12,200 |
| | GENERAL QUANTITIES | |
| 27. | Total water evaporated from syrup, per pound of steam supplied | 778 |
| 28. | Total water evaporated per square foot heating surface, per hour | 16.12 |
| 29. | Temperature fall, actual | 115.8 |
| 30. | Coefficient of heat transmission | 166.3 |
| 31. | Cooling water per pound of vapor | 15.04 |

---

*All temperatures are in degrees Fahrenheit.



GRAPHICAL LOG, TESTS OF A 13-FT. EXPRESS VACUUM PAN

## Heat Balance

| | |
|---|---|
| ENTERING | |
| Heat entering in steam, B.t.u's | 109,849,154 |
| Heat entering in syrup, B.t.u's | 15,089,800 |
| Entering, total | 124,938,954 |
| LEAVING | |
| Heat leaving in masse-cuite, B.t.u's | 4,514,209 |
| Heat leaving in vapor, B.t.u's | 82,127,783 |
| Heat leaving in condenser steam, B.t.u's | 22,328,208 |
| Heat leaving, total | 108,970,200 |
| Heat lost in radiation and not accounted for | 15,968,754 |

# Electric Iron Smelting at Hardanger in Norway

BY JOH. HÄRDÉN

Mr. G. Oedquist has in an interesting and suggestive paper,[*] read before the Polytechnic Society of Kristiania, Norway, given a comparatively full report of the facts which, according to his mind, have caused electric smelting to give an unfavorable result at Hardanzer, in Norway, as far as the economy goes.

As the paper is evidently written with the view to lay clear such instances as are likely to occur in other places, a résumé of the contents seems justified; a few remarks of the present author's experience on similar lines will be added. The main points of Mr. Oedquist's paper are:

Since the problem of electric smelting of iron ore has the greatest future and importance for such countries as Scandinavia, on account of the tremendous sources of both water power and deposits of high-quality iron ore (which factors are essential for the success of electric smelting), it is well worth while to go into the causes of the unsatisfactory outcome of the trials, so far made at Hardanger. A few comparisons will be made between this plant, where coke was used exclusively, and a few others, where charcoal is used.

The author of the paper in question does not mention the facts that the choice of reducing agent—coke versus charcoal—is an important factor in the whole problem, yet all available data seems to point out that this must be so, at least for the present, and it appears to the present author that the coal question is of at least as much importance as the question of cheap power and good ore.

As far as can be concluded from the various reports, the operation with coke direct in the furnace has essential drawbacks, some of which appear in the report, as will be seen. In the first place, the conductivity of the coke is high, hence a large current density at a lower voltage is likely to be required, and this will in turn increase the electrical losses and cause the plant to be more expensive, with a lower efficiency. This is borne out by the paper, as will be seen. Further coke is always richer in sulphur and, therefore, demands a larger addition of lime, which increases the dead ballast in the furnace, thus lowering the output; this is also mentioned, though in a somewhat different way. True, coke may be obtained with a low percentage of sulphur, but such coke is much more expensive and throws the balance the wrong way.

Against this, charcoal is much more suitable, on account of its lower conductivity, low content of sulphur, and its gas producing properties. But charcoal is expensive, even at its best, and there is likely to be difficulty to obtain a proper supply of charcoal in Norway, especially at places like Hardanger, where the other factors may be more favorable; hence if charcoal were to be used, it must be subjected to import or long freight, but this burden it cannot very well bear on account of its initial price and its bulky mass.

Even in Sweden, where charcoal may be obtained more readily, the question has become "a burning problem." It is reported elsewhere that owing to the large demand for charcoal wood, the manufacturers are gradually forced to make use of younger, quick-growing trees, on which the percentage of bark is rather high. As the bark contains a larger proportion of phosphorus, this obnoxious element is introduced into the otherwise pure ore and tends to lower the quality of the product. One should think that the phosphorus should be eliminated in the charring process, but report says that this is not so, and to remove the bark would mean an increased cost and loss of material.

This, of course, does not apply so much to charcoal made from refuse from saw mills, since the wood is generally barked before putting it through the saw mill; but it is generally assumed that the coal from "natural" wood has a higher value, if made from the right kind of wood.

From this it would seem that the coal question for electric iron smelting is a very important one.

But to recur to the paper under review, it is stated that the conclusions in the report are made from official statements, made by the Electrometallurgical Committee regarding the trials at Hardanger, and may be found in *Teknisk Ugeblad*, 1913, page 192.

Mr. Oedquist concludes that reading through these statements one cannot help arriving at the surmise that everything was relatively well and good, and that the poor results were to be found here to "misadventure" and outside conditions, particularly to the use of unfavorable ores in some cases, bad roasting of the ore, some of the electrical details not being suitable, unfavorable conjunctures and high freights.

Regarding the furnace type, however, and its adaptability for coke, the committee maintains that this has no part in the failure.

Mr. Oedquist in his paper does not agree with the committee on that point, but thinks that on the contrary the type of furnace design and its unsuitability for working with coke has had a great effect upon the results and in a high degree caused the expectations made at the Hardanger works to be a disillusion.

He endeavors to give strength to this claim in his paper and to explain in what way he has arrived at this conclusion.

As regards the unfavorable conjunctures referred to, the author of the paper says, he does not intend to go into this question at large, nor the freight conditions, as it is outside the scope of his issue; he will only mention that these conditions are always subject to changes and must be taken into consideration *a priori*. Especially as the Hardanger works has only taken a part of the whole program laid out in the prospectus. However important these factors may have been, one must look deeper into the matter in order to find the actual reasons for the unsatisfactory results obtained.

Proceeding to do so, the author commences with some scathing remarks regarding the electrical equipment at Hardanger.

The committee says in regard to this that the choice of transformers and regulating arrangements very soon proved to be unsuitable for the purpose. Furthermore, the manner in which the leads were laid out from the secondary to the furnaces, and the way the connections to the electrodes were carried out, caused the system to work under such bad conditions, that only about two-thirds of the power contracted for was available at the furnace. The committee adds:

"As the plant was carefully inspected electrically before taken into use, without any mentioning of these faults, one was led to believe for a long period that the bad results were due to faulty operation of the furnace itself. Only later, as the conditions were tested in a proper way, it was found that a power factor of only 0.60 was obtained."

Consequently, under the whole of this period, the first furnace was working with a power factor of 0.60, and it was only in January, 1913, shortly before the second furnace was to be started, that the leads were laid differently and the carbon arrangements altered so as to give a better effect.

The arrangement of the transformers and the regulating system remained unaltered, however, as their change would have caused too much expense.

---

[*] A second part of the paper was also read, but has not yet been published. The first part, which is discussed in this article, has been published in *Teknisk Tidskrift*, December, 1913

The voltages on the secondary side could be regulated between 50 and 78 volts.

These appear to the present author to be too high average values. Compared with other three-phase furnaces, operating under conditions which would call for a higher voltage than required in a closed iron reduction furnace, it is found that the highest voltage required when starting up and while the furnace is still cool is 62 volts, while the normal working voltage after the first two or three hours, with a normal slag, is just under 50 volts, or even down to 45 volts. Hence it seems very likely that a regulation of from 30 to 65 volts would have been much more advisable, perhaps with a small auxiliary voltage raiser for a few per cent of the total power only, to be resorted to in cases of emergency, to break through the resistance of a stubborn charge.

It is true that such a lower range of voltage on the secondary would have rendered the construction of the transformers more difficult and would have increased the cost of the plant at first, and it is quite likely that this consideration may have tempted to instal the higher rating; but on the other hand, with a plant as the one in question, it seems a dangerous policy to save at the start and to risk the life of the enterprise in the end.

According to the paper, the Electrometallurgical Committee which visited the plant in April, 1913, when some of these faults had been corrected, carried out some measurements on the second furnace. The power factor was then up to 0.91 and the electrical efficiency 0.885 per cent at a pressure of 78 volts.

At 50 volts, however, it was found that the normal load on the furnace was unattainable and both the power factor and the efficiency were low (though the actual figure was not stated).

The consequences of the above statements are that as far as the first furnace is concerned 33 per cent, at least, of the total power contracted for was not available in the furnace, on account of unsatisfactory arrangements.

The present author thinks that the above conclusion is not strictly proven to that extent, as the lowest working figure is not given; and although the power factor was rather low, it would mean wattless current which is, of course, not paid for, unless a lump sum is paid for a certain quantity of power, held available at the supply works, but this is not stated.

The second furnace was started in March, 1913, and showed the advantage of a better power factor and higher efficiency, at least as far as the higher voltages are concerned.

That the output of this furnace, however, in spite of this, was not higher than 1.87 ton pig iron per calculated horse power year during March depends on other causes, which the reporter proceeds to explain later on.

In order to show the results at Hardanger more clearly, some curves are issued, made by the electrical committee and based on the calculated figure of a 70 per cent useful efficiency of the furnace per hp year, arranged for various per cent of pig iron calculated on the charges of ore, limestone, etc. One of these curves is shown in Fig. 1.

The upper curve refers to furnaces in which one has 33 per cent of $CO_2$ in the furnace gases; the lower curve refers to such where the gases are chiefly CO.

Certainly other factors than the percentage of iron alone govern the output, namely the degree of oxidation of the ore and its assay in general, the analysis of the pig iron and the slag, etc., but as the percentage of iron is the most important, the other factors have been so far left out of consideration, and the diagram as shown has been adhered to, in order to simplify the understanding of the conditions.

For comparison a few points from other plants are drawn in, namely from the results at Trollhättan ($T_1$ and $T_2$), from Strömsnäs trials (also at Trollhättan) marked (S), from Uddeholm ($U_1$ and $U_2$) and the results from Hardanger (H) during the period March 2 to March 28.

During the last mentioned period at Hardanger, no gas circulation was used in the furnace, wherefore these results actually belong to the lower curve, and from this will be seen that the furnace was only utilizing about 70 per cent of the power supplied; a higher figure is very unlikely to be obtained with this furnace under the prevailing conditions.

It is to be remembered regarding these figures that they refer to the furnace in full operation during the whole period, so that the 70 per cent do not include any stoppages or heating up, repairs, etc. Also it is calculated on the total energy actually supplied to the furnaces, not on the amount which must stand available at the transformers for emergency, etc.

The author of the paper calls this figure of efficiency "apparent" efficiency, which should not be regarded as the efficiency of the plant and should not be laid as basis for estimating the whole results of the works. This is only natural, as the figure obtained for any one single furnace during a short period cannot be regarded as a measure of the conditions of the complete plant, since the furnaces and periods of smelting differ; besides power may also be used elsewhere than on the furnace terminals.

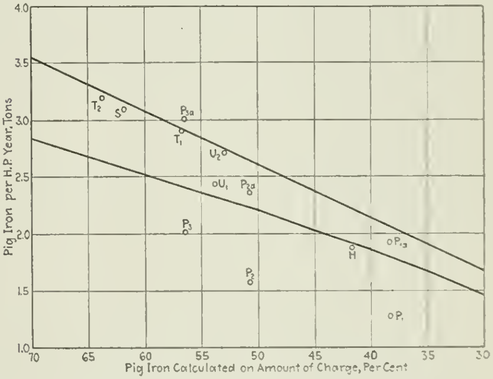


FIG. 1—RELATION BETWEEN POWER CONSUMPTION AND PERCENTAGE OF PIG IRON IN CHARGE

All values given in the diagram No. 1 are figures based on this principle.

The work carried on at Hardanger may be divided up into three campaigns or smelting periods, whereby period III is a part of period II, and the yield during these periods are shown in Table I.

Table I.

| No. | During the period | Per cent. of iron against the charge | Tons of pig iron calculated per H P. year |
|---|---|---|---|
| Period I.— | | | |
| | From Nov. 7, 1911, to April 13, 1912 | 38.1 | 1.28 |
| Period II.— | | | |
| | From July 10, 1912, to Feb. 20, 1913 | 50.7 | 1.58 |
| Period III.— | | | |
| | From Aug. 25, 1912, to Sept. 8, 1912 | 56.4 | 2.01 |

The figure for the power in this table is taken from the *primary* side of the transformers and, therefore, include the losses in these as well as in the copper connections and electrical equipment of the furnace.

These results are found in Fig. 1 under the marks $P_1$, $P_2$ and $P_3$.

In consequence of the faults in the electrical arrangements already stated, the actual quantity of power used in the furnace proper only was about two-thirds of the recorded power, and if this is taken into consideration, the figure for the yield may be altered so as to read (about) 1.92, 2.37 and 3.015 tons, respectively, per calculated horsepower year for the three periods, respectively.

The corresponding values are shown in Fig. 1 under $P_1a$, $P_2a$ and $P_3a$.

As will be seen from Fig. 1, the results of the periods I and II stands between the two actual curves, and as the gas circulation is recorded as being rather low, one may be justified in assuming that the "apparent" efficiency in both cases was approximately 70 per cent.

The point "$P_3a$" stands somewhat over the upper curve, but as this gives the "apparent" efficiency of 70 per cent at a gas proportion of 33 per cent $CO_2$ and as the proportion of $CO_2$ is given in average to be 39 per cent one may also here assume an average efficiency of 70 per cent.

Consequently both furnaces seem to have given an "apparent" efficiency of 70 per cent after the losses due to faulty arrangement of connections, etc., have been deducted. It may be mentioned that the measuring instruments in the plant show a slight error, but this is of minor importance on the whole.

It is noteworthy that these results follow the calculated curve fairly well, wherefore it is safe to say that the efficiency of this type of furnace will in the average give 70 per cent apparent efficiency generally.

The diagram Fig. 1 shows clearly how the faulty electrical arrangements influenced the output on the first Hardanger furnace; and not only this, but these arrangements were of great importance upon the other working conditions, at any rate indirectly.

As one of the indirect consequences may be mentioned the large

### Percentage of Scrap

produced. The Electrometallurgical Committee has drawn attention to the difficulties connected with the tapping of the furnace and proper maintenance of the taphole, and that it was often necessary to disconnect one of the phases in order to obtain sufficiently high voltage to melt out the taphole.

This proves that it was difficult to obtain a sufficiently high temperature in the furnace, and this is quite likely, since a furnace which is designed to receive a certain quantity of heat electrically and which is only receiving about two-thirds of the power, will of necessity run rather cool.

The consequences were also inevitable, and it seems quite permissible to lay the chief fault of the high percentage of scrap produced to this cause.

Table II shows the amount of scrap produced:

TABLE II.

| | Percentage of scrap counted on total output | Smelting stopages in per cent |
|---|---|---|
| First Furnace— | | |
| Period I | about 25% | 20.8% |
| Period II | " 20% | 8.5% |
| Second Furnace— | | |
| Period IV, March 3 to March 28, 1913 | " 10% | 14.0% |
| Period V, April 26, 1913, to June 28, 1913 | " 5% | not stated |

The percentage of scrap from the second furnace is visibly smaller than that from the first, and this must be due to the more efficient way in which the conductors are laid and to the better electrical arrangement generally, whereby it was possible to increase the power in the furnace, as compared with the first furnace.

The interruptions in the smelting play, of course, also a considerable part in this respect, but lack of sufficient heat is more important, as is evident from a comparison between period IV and II.

Truly the stoppages are only taken in hours proportionate to the total period, without stating the numbers of stoppages, but we must assume that the figures given represent the approximate influence of the interruptions. What influence this large percentage of scrap has upon the whole economy of the plant is unnecessary to point out. It speaks for itself.

### The Gas-Circulation

The above-mentioned difficulties in obtaining a sufficient heat in the furnace may probably also have accounted for the fact that the gas circulation was discarded subsequently at Hardanger. It was found necessary to increase the heat in the furnace at all cost and as one of the means to do so was the abandoning of the circulating of the gas, this was given up by and by.

The circulation of the gas causes, as is well known, a lowering of the temperature in the furnace cavity, because a certain quantity of heat energy is used up by the reaction of the $CO_2$ with the heated carbon, forming CO, which is a heat-binding process; further, heat is expended by raising the mass of gas up to or near the temperature of the smelting zone, which heat is then carried up in the shaft.

Of course, a part of this heat is recovered through the preheating of the charge, but as the gases strike rather rapidly through the shaft, a good deal of heat is carried further away, outside the furnace. Hence the gas circulation will lower the temperature in the smelting zone and raise it in the shaft, with the consequence that if gas circulation is employed the gases leaving the furnace will contain more of $CO_2$ than otherwise, which again influences the coal consumption and the power consumption in such way that both of these factors will be lower if gas circulation is used.

The author does not prove this statement by figures. It is clear from his reasoning that the coal consumption should be lower, but it is not equally clear that the *total* power consumption for the whole furnace should be lower, although the process is less heat requiring as far as the actual reduction of the ore goes, if the final gas product is higher in $CO_2$. Against this stands the heat expended in dissociating the $CO_2$, raising of the temperature of the gas mass and alteration of the direction of the heat gradient.

This question could without doubt be answered by means of the results obtained at the trials of the Swedish Iron Institute at their plant at Trollhättan, but the author of the paper has not made a comparison.

As the gas circulation was abandoned, in order to obtain a higher temperature, the coal consumption increased from 336 kg coke per ton of pig iron *with* the gas circulation, to about 385 kg *without* same.

The power consumption increased as well, which can be seen from the diagram, Fig. 1, where the lower curve gives a fair indication of the amount of power without the gas, and the upper curve with the gas.

But as the temperature of the furnace was of a much higher importance one had to give up the advantages of the gas circulation and it appears that the management arrived at the conclusion that it would be generally better under the prevailing circumstances to carry out the process without the gas circulation all together, because after alternative runs with and without circulation for a time, it was not used again during the period after December 14, 1912.

But, as will be seen from the above, the circulation of the gas has a greater importance as soon as the conditions are adequately arranged to obtain a good heat electrically in the furnace cavity.

If, therefore, the abandoning of the circulation was justified for the first furnace, in order to raise the temperature the case is different with the second furnace. Since the electrical arrangements had been altered here, it ought to have been possible to obtain the proper heat even with gas circulation, and so obtain the advantages of gas circulation.

As the diagram Fig. 1 shows, when gas circulation is used, so that the furnace gases contain about 33 per cent $CO_2$, the output per calculated horsepower year can be raised by 15 to 25 per cent.

Of course the circulation may cause other difficulties, but as regards the so-called "slig," i. e., the wet or dry, powdered ore concentrate from which briquets are pressed, the experience at Hardanger seems to indicate that their employment offers no particular difficulty which would prevent the use of gas circulation, as it was stated that the average gas pressure was about 300 millimeters water gauge.

Should, however, the conditions be so that all the furnace gases may be utilized for power, etc., one may be able to recover a part of the heat energy expended this way.

### The Ore Used

It has been pointed out from many sides how important it is to use a high-grade ore for the electric smelting and that the content of iron in the charge will greatly influence the electrical efficiency; this is also very fully demonstrated in the diagram Fig. 1.

It is in most cases more advantageous to concentrate a poorer ore for use in the electric furnace, so as to eliminate the bulk of the dead gangue previously; this is as a rule quite clear, since the gangue forms a heavy ballast, which increases the slag and the total losses and taxes the furnace unnecessarily.

If coke is to be used as a reducing agent, it is necessary to work with a very basic slag in order to obtain a pure material. The addition of lime is, therefore, larger, and will cause a decrease of the percentage of iron in the charge, wherefore in that case it is still more important to use high-grade ores; it is also rather important to use an ore with a lower percentage of quartz, so as to avoid a larger addition of lime.

It seems most advisable to use a mixed ore of basic and acid nature, so that the quantity of lime may be minimal on account of the ore. Of course, one must see to it that the quantity of slag will not be too low; this, however, is less dangerous with electric smelting, as the slag is of less importance here than with ordinary blast smelting.

A number of other features of the ore used are more or less essential for good working of the electric furnace; but as the author says, it would carry us too far to discuss these here. Each kind of ore should be carefully investigated in this respect previous to the smelting.

The author is no doubt quite correct in this respect; but as the practical experience has shown, it is very difficult in the daily routine of work to carry out proper investigation in each case, especially if a greater variety of ore is delivered for smelting; much time and a large staff would be required. This was hardly necessary at Hardanger, where ores of fairly even contents without doubt could be obtained.

The price one should pay for the ore is, of course, regulated by the iron content and its adaptability for good smelting, and it is certainly not self evident that a cheap pig iron can be made from a cheap ore. Therefore, the classification of the ore is governed by the actual results of smelting only, local conditions being considered as well.

Four different ores were used at Hardanger, namely, Klodebergs ore, "red sand" concentrate, and briquets from Sydvaranger, all from Norway, as well as ore from Persberg in Sweden.

These ores were used in proportions given in Table III.

TABLE III

| Period | Ore | Per cent Fe in the ore | Per cent of ore charged | Pig iron produced in per cent of charge |
|---|---|---|---|---|
| Period I | Klodebergs ore . . . . | 45 | About 96 | 38.1 |
| | Red sand concentrates . | 64.5 | " 4 | |
| Period II | Klodeberg ore ........ | 45 | " 22 | 50.7 |
| | Sydvaranger briquets... | 64 | " 56 | |
| | Red sand concentrates.. | 64.5 | " 22 | |
| Period III | Sydvaranger briquets... | 64 | " 88.5 | 56.4 |
| | Red sand concentrates . | 64.5 | " 11.5 | |
| Period IV | Persberg ore ......... | 53 | " 56.5 | 44.6 |
| | Red sand concentrates.. | 64.5 | " 43.5 | |

The Klodeberg ore, which was used almost entirely during period I, and also to some extent during period II, contains about 0.3 per cent of zinc, and this caused a certain amount of difficulties at Hardanger; but apart from this, this ore is rather poor and therefore gives, as the table shows, a low output under period I, only 38.1 per cent.

Hence, if this ore is not exceptionally low in price, it appears to be rather unsuitable for a smelting operation in general.

The briquets from Sydvaranger are prominent on account of their high percentage of iron, and also low content of sulphur and phosphorus. They would, therefore, be regarded as particularly suitable for this process, but the price is so high that it is scarcely likely that it will be economical to use this ore as staple ore. It is, however, most suitable for enriching other poorer ores.

It was stated as a considerable disadvantage at Hardanger, that the briquets delivered were falling into smaller pieces and sand, but it is to be expected that this will be improved upon so that the briquets will arrive in a sound condition.

The red sand concentrate is also characterized by a high percentage of iron and low content of phosphorus, and as it probably can be obtained at a reasonable price, it should form a good staple ore. It has, however, the disadvantage that it contains a good deal of sulphur, wherefore roasting is necessary, and this, of course, increases the cost somewhat.

It was intended at Hardanger to roast this ore on the spot and to agglomerate it at the same time. This, however, met with difficulties; although the de-sulphurization was very effective, it was not possible to cause the ore to stick together to any great extent, wherefore it was necessary to charge the ore in a fairly divided state instead of in lumps as intended, and this, of course, caused a considerable alteration in the original smelting program.

In any case it should be possible to smelt a charge with a considerable percentage of concentrate, if no gas-circulation is used, probably even up to 75 per cent of total ore.

The author of the paper does not consider this fact to be a cause of the previously mentioned abandonment of the gas circulation; this is, however, not entirely out of question, as regards the second furnace, where a higher temperature was otherwise obtained, and Table III shows that a certain amount of this concentrate was used during that period.

In spite of the high percentage of Fe in both Sydvaranger and red sand ores during period II the output was, on account of the poorer Klodebergs ore, only 50.7 per cent.

During period III, when only Sydvaranger and red sand ore was used, the output increased to 56.4 per cent.

The reader may be reminded here that in the trial smeltings at Trollhättan and the Strömsnäs Iron Works, the yield was mostly higher, namely, about 62 per cent, and in some cases up to even 75 per cent.

It is, of course, easier to obtain a higher yield when the smelting is carried out with charcoal and a charge which does not require a large addition of lime, as compared with coke-smelting.

The Persberg ore was used during period IV in the second furnace. Although this ore is a good ore in itself, the author of the paper does not regard it very suitable for the case in question, and he gives the following reasons for this opinion.

In the first case, it only contains about 53 per cent Fe, and, secondly, it contains such a considerable amount of silicious matter that a large amount of lime is required to obtain a basic slag, such as is required with electric smelting. This is shown by the fact that although the ore was considerably enriched with the red sand concentrate, only 42 per cent pig iron (in per cent of charge) was obtained; besides the freight cost will no doubt be rather high.

It is, therefore, not said that this ore is unsuitable for electric smelting. On the contrary, where charcoal is used, and a very basic slag is not required, it should give good results if mixed with richer concentrates.

The author proceeds to show by example how important it is economically to use a charge with high percentage of Fe, and compares the results with different ores.

This comparison is best made between a modification of the conditions at Hardanger during period I and corresponding conditions for period III.

As only a smaller quantity of red sand concentrates was charged during these periods, one can regard period I as representing Klodebergs ore with about 45 per cent Fe and period III Sydvaranger briquets with about 64 per cent Fe. We may further surmise that the furnace in both cases is operating with gas-circulation and about 33 per cent $CO_2$ in the issuing gas without any difficulties, and that the apparent efficiency is 70 per cent. Under such conditions the output per year is represented by the upper curve in diagram Fig. 1. During period I, with a charge giving a yield of 38.1 per cent Fe, we should have an output of 2 tons, and for period III, with a yield of 56.4 per cent Fe, we should get 3 tons of pig iron, all calculated per hp-year.

If we assume a price of $8.25 per hp-year (which is quite permissible), we find that power cost per ton of pig iron will be, in the first case, in round figures, $4.12, and in the second case $2.60.

Consequently, the price of electric power alone, per ton of pig iron made from the low-grade ore, is higher by $1.50 as compared with the production of iron from the richer ore.

(The actual difference total is very much higher, which will be shown in Table X, which is given in the second part.)

Furthermore, during period I only 43.8 per cent of pig iron was produced from ore proper (this figure is rather low, if the analysis of the ore is considered), and in period III 69.1 per cent. In other words, in order to obtain 1 ton pig-iron one requires 2.3 tons of the low-grade ore and 1.45 tons of the richer ore.

If the extra cost of handling of the larger quantity of ore and slag are duly taken into consideration, as well as other expenses connected with the smelting of a larger quantity of low-grade ore, one is justified to conclude that for the case in question the Klodebergs ore should only demand one-half, at the most, of the price of Sydvaranger briquets.

### Electrode Consumption

The consumption of electrodes at Hardanger, compared with other works, is shown in Table IV, where the consumption is given also for the works at Uddeholm and the before-mentioned furnace belonging to Strömsnäs Iron Works, both in Sweden.

TABLE IV.

| Plant | Electrode Consumption in Kilogr. | | |
|---|---|---|---|
| | Per ton pig iron | Per day, total 24 hrs. | Per 24, working hours |
| Hardanger, Period I............ | 29.7 | 170 | 215 |
| Hardanger, Period II........... | 16.3 | 156 | 172 |
| Hardanger, Period III.......... | 11.1 | 134 | 138 |
| Hardanger, Period IV........... | 41.84 | 439 | 510 |
| Uddeholm, Furnace I, March 15-December 31, 1912 .......... | About 9.0 | About 151 | About 158 |
| Uddeholm, Furnace II, August 4-December 31, 1912 .......... | " 7.0 | " 135 | " 141 |
| Strömsnäs , Oct. 1-Dec. 31, 1912.. | 2.78 | 58 | 59 |

The heavy figure for period IV is stated to have been caused by an unusually bad delivery of electrodes, and the Electrometallurgical Committee states that the actual consumption of electrodes, after all breakage has been deducted, is only about 14 kg per ton of pig iron, instead of 41.84 kg. This would correspond to about 170 kg per twenty-four working hours.

As the author of the paper does not state anywhere of what capacity the furnaces were in either case, it is not entirely fair to draw a comparison between the plants, as a furnace of a smaller size will give a different figure compared with a larger, though, of course, the consumption per ton of pig iron is a deciding factor in all cases.

It is clear that the consumption of electrodes is greater when a lower-grade ore is smelted, which would perhaps explain the difference between the 14 kg for period IV and 11.1 kg for period III, when a richer ore was smelted, but on the other hand, the electrode consumption is greater when gas circulation is used, which would have had the opposite effect.

It may be presumed that the electrode consumption is increased when coke is used as reducing agent, and in this case the arrangement of the electrodes should be specially considered. This fact seems to be more or less proved by the frequent breakings of the electrodes at Hardanger.

As has been stated in another report, the furnaces at Hardanger carry six electrodes, as is also the case at Uddeholm, while Stömsnäs furnace has only four. The advantage of using six electrodes, which give a better distribution of heat, is obvious when coke is used. But as far as the experience now shows, the electrode consumption is hereby considerably increased.

The electrodes at Uddeholm and Strömsnäs have the same diameter as those in Hardanger, namely, 500 millimeters (about $19\frac{3}{4}$ in.) and as the power consumption does not differ considerably, each electrode has a much smaller working current density when six are used instead of four. In other words, at Hardanger as well as at Uddeholm, a larger electrode diameter than necessary for the energy supply has been used as compared with Strömsnäs, and the question arises whether the electrode consumption would not have been lower if electrodes of smaller diameter had been employed so that the current density per square inch had been the same as in the Strömsnäs furnace.

Sufficient data for a satisfactory reply to this question are at present not available, but the results from Strömsnäs are certainly significant though several causes must have added to the good results in that plant, for example, specially good quality of the electrodes and similar causes.

Luton, England.

# Fine-Meshed Brass Gauze as a Substitute for Platinum in Electro-Analysis

BY D. F. CALHANE AND T. C. WHEATON

The following article describes a successful substitution in several cases of electro-deposition of metals, of brass gauze as cathode in place of the ultra-expensive platinum. The methods of analysis that will be described have been given two years' tests in this laboratory and found to work well in the hands of students. A great deal has been published on rapid methods of electro-analysis using rotating electrodes and in some cases on methods where the torque of a magnetic field is employed to stir the solution and permit of large currents being used.*

Among the first to notice the value of gauze for cathodes was Winkler in 1899, who stated that the use of platinum gauze as cathode in place of the cones, cut down the time to one-quarter, since large currents could be successfully employed.

Frary also made use of cathodes of platinum, silver and copper gauze in his solenoid apparatus. (Jr. Am. Chem. Soc., vol. 29, p. 1592.)

Stoddard (Jr. Am. Ch. Soc., vol. 31, p. 385) confirmed the work of the previous writers and held that with strong currents and no rotation the heat and gas evolution stirred the solution very adequately. This has been found to be true in our work.

It has been difficult to find a good substitute for platinum. Frary, as previously mentioned, used nickel, copper, and silver gauzes in the deposition of zinc.

J. W. Turrentine[1] proposed the use of graphite cathodes and anodes in place of platinum. These worked fairly well, but with high current densities the graphite is apt to flake and become porous. Sherwood and Alleman[2] used a cathode of stamped tin in the determination of zinc, copper, silver, cadmium, and nickel.

Poweck[3] tried mercury-coated zinc or brass gauze electrodes in the determination of zinc with favorable results. In our work a very fine brass gauze of 100 mesh to the inch was employed. It was copper-coated beforehand. The advantage of the brass gauze is that it is obtainable in finer mesh than copper gauze, and so, for a given size, presents more surface, permitting of large current and thus improving the time factor. Further, it is tougher and is comparatively the cheapest gauze that can be used. At retail its present cost is 80 cents per square foot, and this will make 6 electrodes of the size to be described. With proper care they last for a long while.

One set for a class can be discarded at the end of the term and the cost to each student is insignificant. One of these electrodes worth 20 cents has been used for 30 determinations of copper and is still in good condition.

## Preparation of the Gauze Electrodes

The brass wire cloth is cut into pieces $5\frac{1}{4}$ in. long and $3\frac{1}{4}$ in. wide. The longer edges are lapped over and hammered down. The shorter edges of the gauze are bent over a 12-in. loop of No. 22 copper wire, and the ends of the wire twisted together, thus forming a cylinder, weighing about 12 grams.

The gauze cylinder is placed in a caustic bath to remove grease, rinsed and then plated in a copper sulplate solution for a few minutes, using a current of 2 or 3 amp.

The gauze is then washed, dipped in alcohol, dried and weighed.

For ammoniacal solutions a platinum wire insert is used in the copper wire stem, which will otherwise be attacked by the ammonia fumes near the surface of the solution.

Only two pieces, each 3 in. long, of platinum wire are needed. These are attached to the brass gauze cathode and twisted together. Their other end is joined with the copper wire stem. The approximate area of one of these cathodes is 64 sq. centimeters, calculated from the formula $S = 2\pi Deb\sqrt{\frac{l}{n}}$ (Winkler, Berichte, 32, 2192), where $S$ is area, $D$ is diameter of the wire, $l$ is length of gauze strip and $b$ is its width, or height of the cylinder, and $n$ is number of meshes per sq. centimeter.

The area is not the whole factor responsible for the efficiency of the gauze, as a plain surface 5 x 3 in. would offer nearly 97 sq. cm. surface. It undoubtedly lies in the nature of the surface of a gauze facilitating the rapid elimination of hydrogen, with large currents, thus giving a stirring effect and increasing the rate of migration near the surface of the gauze. Investigation of this problem will be carried out in this laboratory.

The procedures and results in the cases of copper, nickel, and zinc determinations will be given.

Analyses for copper were made from silver alloys, German silver, nickel-copper alloys and copper scale that was contaminated with iron and other impurities.

It was found in the case of silver and copper determinations in potassium cyanide solution that at low potentials between 2 and 3 volts for the deposition of the silver, the brass gauze could not be used as the zinc dissolved, and silver was deposited.

The potential separation of silver from copper in cyanide solution was carried out with platinum gauze and then the copper was deposited on brass gauze at 12-15 volts pressure and a current of 1 to $1\frac{1}{2}$ amp. Time, one hour.

| Wt. Cu. deposit | Per cent copper |
|---|---|
| 0.012 | 9.11 |
| 0.0122 | 9.10 |

The procedure in the analysis of copper scale was as follows: About 0.75 gr. of the sample was dissolved in nitric acid. This solution was evaporated to soft dryness and 10 or 15 c.c. of water added. Then the acid still present was neutralized with ammonia and the solution then made acid with $H_2SO_4$ and 4 drops of $HNO_3$ added. The solution was diluted to 150 c.c. and electrolysed, using a platinum wire spiral as anode and the brass gauze as cathode. The spiral was made by coiling up 10-12 in. of thin wire weighing about 1 gram to the foot.

Some of the results obtained were as follows:

| Wt. sample | Wt. deposit | Per cent copper |
|---|---|---|
| 0.4628 | 0.3366 | 72.730 |
| 0.8292 | 0.6035 | 72.780 |
| 0.8097 | 0.5908 | 72,980 |
| 0.8428 | 0.6118 | 72.600 |
| 0.7710 | 0.5610 | 72.75 |
| 0.6781 | 0.4945 | 72.800 |

The current employed was 3 to 4 amp for the first ten minutes and 1 amp for $\frac{3}{4}$ of an hour. A complete analysis could be carried through in $1\frac{1}{2}$ hours. The deposits were excellent, bright and adherent. The above analyses were selected from the work of the Senior class in Chemistry.

Analyses for nickel were made from various materials, e. g., nickel-copper alloys, German silver, nickel anode scrap and resistance wire. In the analysis of German silver alloy, using the brass gauze cathode, it was found possible to deposit completely between 0.3 and 0.4 gram of copper in 45 to 50 minutes, using a current of 5 amp for seven minutes and 1 amp for 40 minutes.

---

*Publications of Prof. Edgar F. Smith, Prof. Classen and their pupils. Smith's Electro-analysis.

[1] *Trans. Am. Electro-chem. Soc.*, 15-505-17, 303.

[2] *Tr. Am. Ch. Soc.*, 1907, 29: 1605-1074.

[3] Smith's Electro-analysis, 1911-119.

| Wt. sample | Wt. deposit | Per cent copper |
|---|---|---|
| 0.5040 | 0.3017 | 59.86 |
| 0.5045 | 0.3020 | 59.82 |
| 0.5000 | 0.2995 | 59.90 |
| 0.5052 | 0.3026 | 59.91 |
| 0.5076 | 0.3043 | 59.97 |

The following procedure was observed in the electrolytic determination of nickel using the brass gauze cathode: About 0.5 gram of the sample is dissolved in a 250 c.c. evaporating dish with 5 c.c. of nitric acid (sp. gr. 1.2). The dish is covered with a watch glass and finally heated on the steam bath when the metal completely dissolves. The solution is then evaporated to dryness. The residue is treated with 4 c.c. of sulphuric acid (sp. gr. 1.84) and heated over an iron plate to expel nitric acid. Twenty c.c. of distilled water are added to the cooled residue, and the dish heated to 60 deg. C. to dissolve all the sulphates.

In a tall 150 c.c. beaker the brass cathode and platinum wire spiral anode are placed and all connections made for a 1 amp current to flow.

The acid sulphate solution is neutralized with ammonia and 30 c.c. excess of strong ammonia added together with a. solution carrying two grams of ammonium sulphate. This solution is poured into the 150 c.c. beaker through a funnel. The current starts at once and the metal is deposited on the gauze, thus preventing any solution of the brass cathode. The cell is now switched over on to a large rheostat and 4 amp allowed to flow for five minutes, which deposits the larger part of the nickel in this time. At the end of five minutes a current of ½ amp is switched on and allowed to flow for the rest of the time necessary to deposit the remainder of the metal. At the end a few drops of the solution are tested for nickel with $H_2S$. A flexible wire is attached to the cathode and this loosened from the binding post and raised slowly from the solution washing with a stream from the wash bottle. The lower edge of the cathode is finally raised from the solution, breaking the electric circuit. The electrode is immersed in distilled water, then in alcohol, and dried at 100 deg. C.

The following data gives results of analyses performed as just explained.

| Wt. charge | Wt. deposit | Per cent Nickel |
|---|---|---|
| 1..0.5823 gr. | 0.5129 | 88.08 |
| 2..0.5919 gr. | 0.5212 | 88.05 |

| Gauze used | Wt. sample | Wt. deposit | Condition | Per cent Nickel |
|---|---|---|---|---|
| 1..Platinum | 0.5983 | 0.5372 | Good | 89.80 |
| 2..Brass | 0.5474 | 0.4917 | Good | 89.82 |
| 3..Platinum | 0.4979 | 0.4368 | Good | 89.76 |
| 4..Brass | 0.5318 | 0.4797 | Good | 89.89 |

The first two analyses were of nickel drillings. The following four examples were analyses of borings from nickel anode scrap. The current was 4 amp for the first five minutes and ½ to ¾ amp for the rest of time, averaging one hour for the maximum time. The deposit were in all cases bright and firmly adherent. It may further be seen that the brass gauze cathode gives exactly as good results as the expensive platinum.

In the zinc analyses a large number of determinations were made, using pure zinc, crystallized zinc sulphate and other zinc bearing material, as alloys such as German silver, impure zinc dust, etc. In all, over 30 determinations were carried out. The solution used was sodium zincate. It was prepared as follows:

The sample was dissolved in dilute nitric acid and then evaporated to dryness. The dish was then heated over an iron plate with 4 c.c. of strong $H_2SO_4$ (Sp. gr. 1.84), leaving the zinc finally as sulphate. The residue was moistened with a little $H_2SO_4$ and taken up in 25 c.c. of water. The following equations show that 4 moles of NaOH are required for 1 part of zinc. A three per cent excess over calculated amount was weighed out.

$$ZnSO_4 + 2NaOH = Zn(OH)_2 + Na_2SO_4$$
$$Zn(OH)_2 + 2NaOH = ZnO_2Na_2 + 2H_2O$$

It was found convenient to make up a solution of standard NaOH of 2½ to 3 normal strength and run in the desired number of c.c. to answer approximately to the calculation for amount of NaOH desired. Say .25 gr. zinc is present, then

$$160 : 65.4 : : x : .25 \text{ whence } x = 6.13 \text{ grs.}$$

of NaOH. Adding 3 per cent excess we have

$$6.13 \times .03 = 0.1839 \text{ gr.}$$
$$6.13 + .1839 = 6.31 \text{ grams of NaOH.}$$

Say the solution of NaOH carries .1 gram of NaOH per c.c., then $\frac{6.31}{.1} = 63.1$ c.c. of solution required.

The gauze cathode and spiral anode were placed in a dry beaker, as in the case of nickel analyses, and the hot solution of zincate poured in through a funnel, the current starting to flow at once. A film of zinc is at once deposited on the surface of the gauze and oxidation prevented. The end of the zinc precipitation may be ascertained by attaching a clean copper wire to the cathode binding post and immersing the end in the solution. If no zinc covering appears after a reasonable time the precipitation is considered complete.

The following are the results of some of the analyses for zinc:

| Wt. substance | Cathode | Wt. deposit | Condition | Solenoid | % zinc |
|---|---|---|---|---|---|
| 1..1.1626 | Brass gauze | 0.2768 | Good | ...... | 23.817 |
| 2..1.0449 grs. | " " | 0.2488 | Good | rotated | 23.81 |
| 3..1.0394 | " " | 0.2476 | Good | rotated | 23.82 |
| 4..1.1429 | " " | 0.2720 | Fair | rotated | 23.80 |
| 5..1.1429 | " " | 0.2720 | Good | not rotated | 23.80 |

The stated amount of crystallized zinc sulphate was weighed out in each case $ZnSO_4.7H_2O$.

In analyses 2-3-4 the solution was stirred by the magnetic field. In 1 and 5 no stirring was employed.

In analysis No. 1 the time was 25 minutes, 5 amp for the first five minutes and 1 amp for 20 minutes.

In No. 2—magnetic stirring—time 35 minutes, 4 amp 15 minutes and 2 amp 20 minutes.

In No. 3, 40 minutes with stirring, 4 amp 10 minutes, 2 amp 20 minutes, 0.5 amp for 10 minutes.

In No. 4—the time was 32 minutes, using magnetic stirring—4 amp for 2 minutes and 0.5 amp for 30 minutes.

In No. 5, no magnetic stirring, time 32 minutes, 4 amp for 2 minutes and 0.5 amp for 30 minutes.

From the results in analyses 4 and 5 it is seen that the magnetic stirring by solenoid does not materially hasten the deposition or improve the character of the deposit.

With the zinc analyses the best procedure was found to be a temperature for the solution of about 60 deg. C., a current of 4 amp for first 5 minutes and 1 amp for rest of time. For an average weight of deposit of 0.3000 gr. of zinc 4 amp for 5 minutes and 1 amp for 35 to 40 minutes was sufficient. The deposits were light-colored, non crystalline, and firmly adherent.

### Summary

It has been shown that the fine-meshed brass gauze is just as efficient as the platinum gauze.

That the time factor for the brass gauze with still electrolyte is very nearly as good as the platinum gauze with magnetic stirring. In fact, the difference in favor of the magnetic stirring is almost negligible.

The brass gauze has been successfully used in the electrolytic determination of copper, zinc, and nickel in various alloys. It gives a very cheap substitute for platinum, costing on the average only about 30 cents per electrode as compared with $19 for a similar platinum electrode at the present price of platinum.

Investigations as to the use of the fine-meshed brass for the determination of other metals will be continued in this laboratory.

Worcester Polytechnic Institute,
Laboratory of Electro-Chemistry.

---

## Concentration of Carnotite by Wet and Dry Methods

A year or more ago, when the carnotite deposits of Colorado and Utah began to attract considerable attention, a number of investigators realized immediately the desirability of effecting a physical concentration of the ore. The comparatively low grade of the ore, the distance from market and expense of transportation, pointed to this necessity. It was not surprising that practically all of the individuals engaged in this work hit upon similar schemes for concentration, but no publicity was given their methods at the time for the reason that they desired to keep them secret.

A little later the Bureau of Mines began an investigation of the deposits to ascertain their value and extent, and the methods of mining and treatment. *Bulletin* 70, recently issued by the Bureau, contains a preliminary report on uranium, radium and vanadium, and gives considerable information on the subject that has not been published hitherto. In addition to describing the deposits and giving the production and prices, the *Bulletin* gives information on methods of testing for radioactivity, and a review of methods of treatment and analysis. **R. B. Moore** and **K. Kithil** are the authors of the *Bulletin.*

The carnotite ores mined and shipped contain between 2 and 3 per cent $U_3O_8$ and several per cent $V_2O_5$. The ratio of radium to uranium in carnotite is about 10 per cent below the normal, which is 1 part radium to 2,940,000 parts uranium. The methods of concentration and results obtained by the Bureau are given below.

### Necessity for Concentration

In the course of investigations of these uranium and vanadium ore deposits it was found that much low-grade ore was left in the mines, and thus lost, and that there was great loss in hand sorting. Since the market demand is for a material containing at least 2 per cent uranium oxide, the miner, that he may ship no ore below this limit, eliminates all ore that in his opinion contains less. As a result much low-grade ore and also some shipping ore are left in the mine or are thrown on the dump. By concentrating the low-grade ores at or near the mine these wastes can be reduced. There is no doubt that the ores can be concentrated. Tests made on a small scale substantiate this statement.

In concentration by mechanical means the dry as well as the wet method may perhaps be used to advantage, as little or no water is available in many places where these ores occur. As formerly stated, most of the deposits are far from a railroad, so that wagon hauls are long and expensive. By concentration the bulk of low-grade ore to be hauled can be reduced and at the same time the percentage of mineral in the concentrate raised to a marketable point. Thus a saving in hauling and freight rates is effected, and the concentrate on account of being richer should bring a better price. Low-grade ores thrown on the dump or left in the mine constitute a natural waste. Much of the low-grade material left in the ground during former operations and perhaps much of the dump material can never be recovered. Much of the ore thrown on the dump disintegrates on exposure to the air, so that much of the valuable contents is washed or blown away. Some of the minerals in the dump rock are liable to be leached out by the rain.

### Wet Concentration

The carnotite ores are of great importance, especially on account of their uranium and radium content. Carnotite, which contains both uranium and vanadium, is a yellow, crystalline, pulverulent material, with a specific gravity of 4.136. It occurs in white sandstone as an incrustation on the faces of joints and fractures and is deposited around and between the individual grains of the sandstone, often strongly adhering to the even surface of a grain. The size of these grains varies greatly, but is generally from a little less than 0.1 to 0.2 mm. in diameter.

In concentrating such an ore the rock should be broken and the pieces reduced to about 40 to 80 mesh with crushers or rolls, the crushing being accompanied by rubbing in order to loosen the carnotite from the sand grains. Further attrition should be applied to the 40-mesh material by convenient means. Fine grinding should be avoided, as it produces too much slime.

If the crushed and rubbed material is washed in a revolving tank or trommel provided with a rubbing device, the particles of carnotite that are in suspension can be drawn off after the grains of silica have settled in the tank or cylinder. As some of the carnotite is carried down by mechanical action with the silica in settling, more water should be added and the operation repeated as many times as may be profitable. With such a treatment a large part of the valuable minerals can be extracted.

The slime is washed into settling tanks or other suitable device, and the water after the settling of the slimes can be used over again, as will be necessary in the arid districts, where most of the deposits are located and where water is scarce. Enough water can be collected and stored away for this purpose from seepage, springs, and during rainy days, and in many cases a wet treatment can in this way be made possible.

### Results of Wet Concentration Tests

Tests have been made of ore taken from the dumps at various claims. In one instance this ore contained 2.02 per cent $U_3O_8$ and 2.32 per cent $V_2O_5$. Concentration by wet method gave the results stated in Table I:

*Table I Results of Concentrotion by Wet Method*

| | Quantity, Grams | $V_2O_5$, Per cent. | Weight of $V_2O_5$, Grams | $U_3O_8$, Per cent. | Weight of $U_3O_8$, Grams |
|---|---|---|---|---|---|
| Ore ............... | 1,943 | 2.32 | 44.08 | 2.02 | 39.348 |
| Concentrate ...... | 191.3 | 9.92 | 18.976 | 8.84 | 16.91 |
| Residue .......... | 1,751 | .... | ...... | .... | ...... |
| | 1,942.3 | .... | ...... | .... | .... |

Loss in concentration, 0.7 gram. Concentration ratio = 10.156 : 1. Extraction from ore by concentration, $V_2O_5$ = 43.035 per cent.; $U_3O_8$ = 43.08 per cent. Ratio of ore to concentrate, vanadium content = 1 : 4 :275; uranium content = 1 : 4.376. Ratio of radioactivity, measured in the electroscope, ore to concentrate = 1 : 4.56, which shows that the concentrate is 4.56 times more radioactive than the ore.

Other tests made with ore containing less $U_3O_8$ and $V_2O_5$ have shown that an extraction can be made with a proportionately similar result.

*Table II—Result of Concentration of Vanadium-bearing Sandstone by Wet Method*

| | Quantity, Grams | $V_2O_5$, Per cent | Content of $V_2O_5$, Grams |
|---|---|---|---|
| Ore ........................... | 400 | 5.57 | 22.28 |
| Concentrate ..................... | 85 | 17.35 | 14.75 |
| Residue ......................... | 315 | .... | .... |

Concentration ratio = 4.72 : 1. Extraction = 66.2 per cent.

The result given in Table II was obtained with a reddish-brown vanadium-bearing sandstone from Utah.

The ore was crushed to the size of the grains, rubbed, and then washed in cold water. The slimes thus obtained were settled and decanted or filtered.

According to electroscopic measurements, and by comparison with a standard material of known $U_3O_8$ content, it was found that this ore contained approximately 0.71 per cent $U_3O_8$ and the concentrate contained 1.62 per cent.

In concentrating this vanadic sandstone the content of vanadium was therefore raised to 17.35 per cent $V_2O_5$ and the concentrate can be sold in competition with the Peruvian patronite. In addition the uranium and the radium can be easily extracted from this ore. Some of the vanadium can not be extracted mechanically; it probably exists in the sandstone as roscoelite, which is bound in the silica.

### Dry Concentration

Where water is scarce a dry process can be adopted for low-grade ores. As good concentration with a dry as with a wet process can not be expected, but an equally efficient if not a better extraction can be obtained.

In a dry process the rock should be reduced with crushers and rolls as nearly as possible to the size of the grains of the sandstone. Much of the carnotite can be obtained by sifting the crushed material through a 120 to 150 mesh screen. Care must be taken to collect all of the dust, as this is richest.

Good results can be obtained by using an air current to blow the finest particles into a dust chamber, in which they are collected. The air current must be steady and evenly expanded, so that the coarse particles will drop out of it, and strong enough to completely lift the material. The coarse material should be carried along with the current for some distance, so that as much as possible of the powdery material can be freed and blown from the coarse grains, which should finally drop without carrying the powder with them. These particles should fall into a discharge spout and thence into bins or other suitable devices. The powdery materials, which carry the valuable minerals, is collected in dust chambers. These chambers must be perfectly tight. Much valuable mineral has been lost in sampling shipments when the sampling device had no arrangement for saving the dust.

A number of machines that doubtless could be used for the dry separation of these ores are now on the market. Another method of dry concentration of low-grade ores consists of simple sifting, with previous rubbing, of the crushed ore. The ore is reduced with crushers and rolls to about 40 mesh and is then passed over an oscillating 150-mesh screen. The undersize from the 100-mesh screen is concentrate. The oversize is carried to a device in which the sand grains are subjected to a thorough rubbing, which removes from the silica the adhering fine particles of carnotite.

*Table III—Results of Dry Concentration by Sifting with Previous Rubbing*

| | Mesh of sieve | Quantity, Grams | $V_2O_5$ content, Per cent | Weight of $V_2O_5$, Grams | $U_3O_8$ content, Per cent | Weight of $U_3O_8$, Grams |
|---|---|---|---|---|---|---|
| Ore | 40 | 500 | 2.40 | 12.25 | 2.24 | 11.20 |
| Concentrate | Under 150 | 134 | 4.66 | 6.24 | 4.42 | 5.92 |
| Residue | Over 150 | 169 | 1.60 | 2.70 | 1.53 | 2.58 |
| Residue | Over 80 | 197 | 1.50 | 2.95 | 1.37 | 2.68 |
| | | 500 | | 11.89 | | 11.18 |

Concentration ratio ore: concentrate = 3.73 : 1; extraction $V_2O_5$ = 50.85 per cent; extraction $U_3O_8$ = 52.85 per cent.

In the experiment stiff wire brushes rubbing against a steel plate were used with success for the attrition. The entire material was then brought over two screens, one overlying the other; the upper screen being 80 mesh and the lower one 150 mesh. Table III clearly shows what results can be obtained by such a process. The screens must be encased and all of the dust must be collected. The dust from the sifting operation and that which remains in suspension in the dust-proof screen boxes can be blown from these boxes by suitable means into dust chambers and then added to the concentrate.

A concentration by this dry method on a small scale gave the results shown in Table III. Care must be taken in crushing the ore for either wet or dry concentration that little, if any, of the dust-like material is lost. Dust chambers should be attached to the crushers, or the latter should have air-tight casings and the material should not be removed until the dust has settled.

### Cost of Concentration

The factors to be considered in a calculation of the cost of concentrating the ore by a wet method are:

1. Cost of concentration: (*a*) Water supply; (*b*) Cutting wood for fuel for power and drying (or cost of gasoline if that is used for fuel); (*c*) Hauling of fuel or gasoline; (*d*) Wages for concentrator men.
2. Amortization of equipment for concentration (pro rata of tonnage of material treated per annum for such equipment and for management.

Two men, at $3 a day each, should be able to operate a small plant. The cost of water supply should not exceed $2 a day. The cutting of fuel or cost of gasoline should not be more than $2 to $2.50 a day. The hauling of the fuel would probably cost $1.50 a day.

On an average, from 10 tons of ore mined only 1 ton of ore with a content of over 2 per cent $U_3O_8$ is obtained by hand sorting. From the other 9 tons, thrown on the dump, about 5 tons of low-grade ore can be separated for concentration. Assume that such low-grade ore contains, on an average, about 1 per cent $U_3O_8$ and 1.5 per cent $V_2O_5$. With a concentration ratio of 10 to 1, half a ton of shipping ore should be obtained. The total extraction of mineral by a wet method should be about 50 per cent, and the grade of the material obtained would therefore be fairly high. In an actual test on such a low-grade ore the percentage of $U_3O_8$ in the concentrate was found to be about 4.5. This should, of course, command a proportionately higher price.

The cost of concentration by the dry process is approximately the same, less the cost of the water supply.

The cost of concentration, including maple charges for amortization and for management, should not exceed $20 per ton of concentrate. These figures are conservative and probably the ores can be concentrated more cheaply.

The average cost of mining with present methods at the rate of 10 tons of ore a day with 6 men and the hand sorting done by the foreman is about $30 per ton of shipping ore. This figure does not take into account the powder used in blasting, the wear of tools, etc. If the grade ore is utilized by means of concentration, the expense of mining is thereby increased little, if any, and only the additional cost for the concentration has to be taken into consideration, the charges for sacking and hauling the concentrate to the station being the same as for a ton of ordinary ore.

From the above it will be seen that through utilizing the low-grade ores the average tonnage per year could be increased 50 per cent with little extra expense. But as the uranium and vanadium content of the concentrate would be at least double that of the average ores shipped, the total production of uranium and vanadium from these ores would be doubled. For various reasons it is hardly to be expected that all of the waste material can be utilized, and therefore such a large increase will probably never be actually obtained.

Perhaps several of the operators could combine and install an equipment for mechanical concentration and treat their low-grade ores in a central plant, especially where several operators are in the same district and the claims are near each other. With such a plant in use the production of marketable ore at the present rate of mining could be increased by about one-half without increasing the cost of mining and with only the additional expense of concentration. This increase can be obtained by treating material that hitherto has been lost.

The assumption, which has been made by many of the dealers, that by concentration a large part of the radium content of the ore would be lost, is entirely without foundation, as no such losses of radium in the concentrate can occur from any mechanical treatment of the ore. This has been proved by the tests of the concentrates. Undoubtedly the statement has reference to chemical concentration, in which, of course, such losses might occur.

## The Power Problem in the Electrolytic Deposition of Metals

A joint meeting of the American Institute of Electrical Engineers, the American Society of Mechanical Engineers, and the New York Section of the American Electrochemical Society was held in the Engineering Building on the evening of January 9, 1914, President Mailloux of the American Institute of Electrical Engineers being in the chair. Each of the three societies was represented by a paper, Mr. Lawrence Addicks defining the electrochemical problem, Mr. F. D. Newbury discussing the electrical engineering side of the problem, and H. E. Longwell the mechanical side.

### The Power Problem in Electrolytic Refining of Copper

This was discussed by Mr. Lawrence Addicks, Superintendent of the U. S. Metals Refining Company, Chrome, N. J. By far the larger proportion of the world's copper is electrolytically refined, and this work is almost exclusively an American industry, centered chiefly in large plants on New York Harbor. These plants are being steadily extended as the annual production of copper increases, and present a power problem well worthy of special attention.

For a copper refining plant we have the following power limitations imposed by present practice:

(*a*) Direct current.

(*b*) Say 8,000 to 15,000 amperes.

(*c*) Say 100 to 200 volts per circuit.

(*d*) Resulting in 800 to 3,000 kw. units—1,000 to 1,500 in present installations.

(*e*) Circuits electrically independent, to avoid cross leakage.

(*f*) Constant current; somewhat variable voltage—say ± 20 per cent.

(*g*) Steady current load night and day.

(*h*) Steam needed for heating electrolyte.

(*i*) Plants of from 3,000 kw. to 9,000 kw. should be considered.

The reasons for these limitations are as follows:

(*a*) *Direct Current:* This is obviously required by the nature of the process.

(*b*) *Amperage:* This is fixed by the current density and the electrode surface per tank. (This paper considers only the so-called multiple system of refining, where the electrodes in a tank are in multiple and the tanks on a circuit in series.) The current density is fixed by a balance between the interest on copper tied up, the cost of power and the difficulties in practical handling of rough deposits.

Fig. 1 shows the approximate relation between cost of power and current density in American practice; the high densities, of course, call for cheap water power. Twenty amperes per square foot of active cathode surface may be taken as representing practice in the vicinity of New York, with an ampere efficiency of 90 per cent and an average consumption of about 1 kw. hour at the switchboard per 6 lb. (2.7 kg. of copper).

Electrode surface per tank has been steadily increased until 30 pairs of electrodes, three feet (90 cm.) square, are used in one case. This calls for a current of 30 x 3 x 3 x 2 x 20 = 10,800 amperes. It is conceivable that higher densities and longer tanks may come into use, so that the author has placed the practical limit at 15,000 amperes, but 10,000 amperes should be taken for a definite discussion.

(*c*) *Voltage:* As we have to deal with a highly conducting electrolyte, containing 10 to 13 per cent of free sulphuric acid, which must be continually circulated to avoid stratification in the tanks, carefully studied construction is necessary to avoid serious trouble from leakage currents. These not only represent wasted energy, as shown by the so-called current efficiency, but wherever current jumps from the electrolyte to a lead pipe or other metallic conductor, a rigidly equivalent quantity of copper is deposited thereon and when traversing acid-soaked wood of relatively high resistance, a quantity of heat sufficient to cause a fire risk may be generated. It must be remembered that nearly the entire electrical energy produced at the generators appears as heat in the tanks. It can be readily appreciated that high voltages greatly aggravate these difficulties. While the author has suggested 100 to 200 volts as the range per circuit, he favors the lower limit and does not believe voltages higher than 150 to be good practice.

(*d*) *Kilowatts:* $10{,}000 \times 150 / 1{,}000 = 1{,}500$ kw. for our typical case. This is a little larger than most of the units at present installed, but represents the probable size for a new installation.

(*e*) *Circuits:* The statements already made regarding current leakage indicate the undesirability of any electrical connection between generators, and the author believes it would be necessary to use motor-generators instead of rotary converters in any A.C.—D.C. scheme distributing power from a large unit over several circuits.

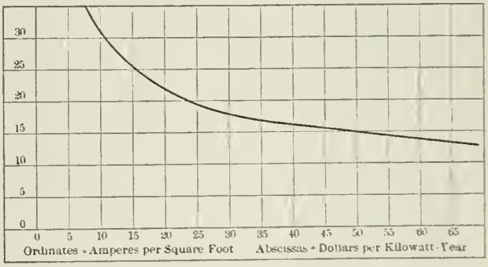


FIG. 1—RELATION OF CURRENT DENSITY AND COST OF ENERGY

(*f*) *Uniformity:* The first principle to be observed in the operation of an electrolytic refinery is uniformity of conditions. The process is very delicate and, while simple in theory, economy depends upon the successful balancing of many conditions to obtain the best results.[1]

In consequence, the current should be held at a fixed value, following variation in the resistance of a circuit with the voltage. Hand control of the field of shunt wound generators is adequate, as the changes in resistance are very gradual. An exception to this statement is the case of cutting out sections of tanks for several hours when drawing copper. It is also necessary to carry up to 2 per cent insoluble-anode tanks, to correct the gradual accumulation of copper in the electrolyte, and as these require about six times the normal voltage for operation, they cause an appreciable variation in the total resistance of the tank house when they are added or withdrawn. To cover this range a field control of our typical generator from 120 to 180 volts at 10,000 amperes will be required. Of course, there will be times when partial or excessive loads will be carried to meet slack or congested supplies of copper, but these conditions are not normal and need not be met with economy.

---

[1] Transactions American Electrochemical Society, 5, 119 (1904)

(*g*) *Load factor:* The operating conditions as described amount to practically 100 per cent load factor for both momentary and 24-hour loads.

(*h*) *Warming electrolyte:* Electrolytes have a high positive temperature coefficient of conductivity. As this amounts to about 0.5 per cent per degree F. (0.9 per cent per 1° C.) and as the electrolyte represents about half the ohmic resistance of the circuit, it is evident that its temperature must be considered. In general, the electric energy dissipated in the tanks will maintain a temperature of 90 to 100° F. (32°-38° C.) and it has been found economical to add sufficient steam in closed coil heating tanks to keep the circulating electrolyte at an average temperature of about 130° F. (54° C.). Exhaust steam can be used, and roughly an amount equivalent to one-fourth of the steam supplied to the engines is required. Additional steam is required for light and power, compressed air, pumping and the manifold requirements of a refining process of which electrolysis is but one step, so that figuring for the moment on the use of live steam for heating the electrolyte, only about one-half the total boiler capacity is used for electrolytic power generation. On the other hand, waste heat boilers attached to the reverberatory furnaces which form a necessary part of every refinery will generate more than enough steam for heating the electrolyte, etc.

(*i*) *Size of plants:* American copper refineries vary from 4,000,000 lb. to 35,000,000 lb. (1,800 to 6,000 metric tons) monthly capacity. At 6 lb. (2.7 kg.) per kw. hour our 1,500 kw. generator would take care of 6,500,000 lb. (3,000 metric tons) per month. Eliminating the smaller plants and allowing for some future extension of the larger ones, we should consider from 2 to 6 circuits of 1,500 kw. each, or 3,000 kw. to 9,000 kw. equivalent to from 13,000,000 to 39,000,000 lb. (6,000 to 17,500 metric tons) copper per month.

Turning now to present practice in the vicinity of New York, we find a very cheap source of fuel in No. 3 anthracite "buckwheat" at $1.75 per long ton ($1.715 per metric ton) delivered. Using this fuel, steam can be produced for about 15 cents per 1,000 lb. (33 cents per metric ton), including all operating expenses, but excluding administration, taxes, depreciation and interest charges. With this base price for steam, a kilowatt hour can be safely figured at 0.4 cent on a similar basis, allowing for auxiliaries and a reasonable departure from ideal conditions in everyday operating. In fact, 0.3 cent can be approached with first-class conditions.

Present practice is to use moderate superheating and vacuum, with the highest-grade reciprocating engines. At the Raritan Copper Works four-cylinder Nordberg triple expansion engines have recently been installed, while at the Chrome plant of the U. S. Metals Refining Company a triple expansion unit using a compound Hamilton-Corliss engine with a Rateau turbine for the third expansion is being tried out. Previous installations have been chiefly confined to compound condensing units. Final figures for these recent installations are not yet available, but Fig. 2 shows about what can be expected from a 1,200-kw. unit of each type, excluding steam for operating condenser.

The Chrome installation is of particular interest on account of the successful commutation of 6,000 amperes (the engine-generator and turbo-generator running in parallel) at 1,500 revolutions per minute by a Rateau-Smoot generator.

The installation cost of such power plants may be roughly taken at $100 a kilowatt, including the disproportionate boiler equipment and auxiliaries.

The plant of the future may consist of gas-driven units, of large-capacity alternating-current turbo-generators driving motor-generators of smaller size, of compound reciprocating engines exhausting into a trunk main from which exhaust steam turbines are fed, of multiple expansion reciprocating engines, of turbine-driven unipolar generators, or of some combination of these. Spare units must be provided in sufficient proportion to give absolute reliability of service.

### Prime Movers for Electrolytic Generators

In his paper on the mechanical side of the power problem in the electrolytic deposition of metals, Mr. **H. E. Longwell**, consulting engineer with the Westinghouse Machine Company, of East Pittsburgh, Pa., said he would confine himself to a general comprehensive survey of the problem from the hilltop of common sense. "In dealing with any technical problem, common sense is most useful; common sense combined with special technical knowledge is doubtless better; but technical knowledge without common sense is disastrous."

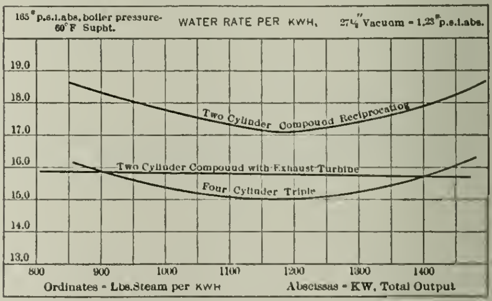


FIG. 2—WATER RATES OF VARIOUS PRIME MOVERS

Mr. Longwell pointed out that any engine the exhaust steam of which is fully utilized can be considered as operating at 100 per cent efficiency. Comparing the performance of a steam-turbine plant with a gas-producer installation, each made up of 1500-kw. units and operating at high load-factors, the author estimated that, using a good grade of fuel containing 14,500 lb-Fahr. heat units per lb., the gas-producer plant would probably show a saving of ½ lb. of coal per kw.-hr. over the consumption of the steam-turbine station. With coal at $3 per ton, this saving of 2 tons per year would effect an economy of $6 per kw.-year, to gain which an extra investment of about $50 per kw. would have to be made over and above the cost of the steam-turbine plant.

Making annual allowances of 8 per cent for interest, 1 per cent for taxes, 1 per cent for insurance, 2 per cent for maintenance and 8 per cent for sinking fund, 18 per cent would be required to insure a return on the investment. As 20 per cent would be desirable, Mr. Longwell pointed out that the saving of $6 per kw.-year effected by the gas-producer units could not be justified unless the differences in initial cost were $30 or less per kw. of installation.

Although it is common practice in copper-refining plants to allow 50 per cent of the steam for the main generating units, 25 per cent for the auxiliaries and 25 per cent for heating the electrolyte, the author declared that since the auxiliaries extract but little useful heat from the live steam, their exhaust can be used advantageously for heating, so that the entire amount for auxiliaries and heating need be only about one-half that required for the main prime movers. In the case of one copper-refining plant which he cited as turning out 500 tons per day the waste heat from the flue gases of the reverberatory furnaces alone is capable of furnishing 50,000 lb. of steam per hour. This steam represents about 40 per cent of that required to run the entire plant and is sufficient for all the requirements of the auxiliaries and the heating of the electrolyte.

Commenting on the theoretical advantages of arranging reciprocating compound engines to exhaust into low-pressure turbines, Mr. Longwell pointed out that the low-pressure turbine costs about 75 per cent more per kw. than the complete-expansion unit. Few triple compound engines, he thought, are enough better than two-cylinder units to make the addition of the intermediate cylinder worth while.

The development of a highly efficient transmission gear for turbines has now made possible the efficient turbo operation of direct-current generators. Several of these geared sets have already been in continuous service for several years, the best known examples being those at San Diego, Cal., Cleveland, Ohio, and Louisville, Ky. While a turbine-driven direct-current unit is more expensive than an equivalent direct-current alternator, it is nevertheless cheaper, said Mr. Longwell, than the combination of turbo-alternator and rotary converter advocated by another speaker.

With careful supervision a really good turbine-driven plant of 6,000 kw. to 9,000 kw. should be built for about $75 per kw., "more or less." Burning coal at $3 per ton and allowing 10.5 per cent for investment charges, it should be possible with capable and reasonably economical management and careful operation at 100 per cent power-factor to produce energy at the switchboard for 4.3 mills per kw.-hr., "more or less."

### Electrical Equipment for Electrochemical Processes

The electrical side of the power problem was discussed by Mr. F. D. Newbury, of the Westinghouse Electric & Manufacturing Company, in a paper on "sources of direct current for electrochemical processes."

The problem involved in producing direct current for electrochemical processes was outlined, and the difficulties are pointed out.

Of the methods of power supply using steam turbines that are available, it was shown that:

(a) Direct-connected d-c. turbo-generators are available only in relatively small units, and cannot be designed as conservatively from the commutation standpoint as is desirable.

(b) Unipolar generators driven by turbines have proven unsatisfactory on account of current collection difficulties.

(c) The standard medium-speed d-c. generator connected to a high-speed turbine through gearing affords a satisfactory unit.

(d) The combined a-c. turbo-generator and converter unit probably affords the best all-around method. It is economical, reliable and flexible. Its particular fields of application are where large units and long transmissions are required.

In waterpower plants, direct-connected d-c. generators and a-c. generators with converters are available. The combined a-c.-d-c. equipment is usually the most reliable and economical. With reciprocating engine units there is no reason for considering other methods than the direct-connected slow-speed generator.

### Discussion

The three papers were discussed together and the discussion was extended, lively, and interesting. Besides President Mailloux, there participated in the discussion Messrs. F. L. Antisell, H. B. Coho, J. B. F. Herreshoff, J. B. Herreshoff, F. A. Lidbury, C. A. Roush and C. H. vom Baur.

Mr. **F. A. Lidbury** said that a plant having an ultimate capacity of 120,000 hp., mentioned by one of the authors, was hardly typical of ordinary electrochemical industries. Only for the manufacture of aluminium are such plants conceivable at the present time. Most electrolytic plants of importance, the aluminium industry being excepted, have a power consumption somewhere between 1000 hp. and 10,000 hp. The electrochemist does not consider it prudent to put, if he can help it, all his eggs into one electrical basket, and consequently in even the largest electrolytic installations (still excepting aluminium plants) the size of units does not often exceed 1000 kw. Under such conditions the conclusions will be different from those reached for a 120,000-hp. plant.

For instance, Mr. Lidbury said, it will no longer be correct to say that "in very few plants can water-wheel generators be located near enough to the electrochemical plant to justify the installation of direct-current generators." It is obviously true that where transportation or other conditions demand the location of the electrolytic plant at a considerable distance from the powerhouse, direct-current generation will be out of question in any case, but where no such condition is involved, it will usually be found not only feasible but the only rational scheme. Mr. Lidbury showed in some detail why for ordinary electrochemical plants he considered direct-current generation quite feasible instead of alternating-current generation with rotaries. "The electrochemical engineer is also apt to have an absurd prejudice in favor of simplicity, and occasionally has been known to evince an unaccountable willingness to pay for it. But there are good reasons for this. Generally speaking, he has quite enough operating troubles of his own without desiring to assume, in addition, the operating troubles of a central station superintendent. What he wants in the way of power equipment is something which will be primarily characterized by smoothness, ease and reliability of operation, and he is apt to know by experience that this is not most likely to be obtained by multiplying the electrical links in his chain of power machinery, or the number of points needing continual attention to insure the best operating results."

Mr. **F. L. Antisell**, of the Raritan Copper Company, said that the efficiency at partial loads should not be overlooked, and called attention to the high operating efficiency of reciprocating engines at partial loads as compared with turbine units.

Mr. **J. B. Francis Herreshoff**, the distinguished engineer and metallurgist of the Nichols Copper Company, said they had had quite a varied experience. Their system at first apparently required small units, and these were supplied with high-speed triple expansion engines, of 400 kw. While they were satisfactory, the cost of maintenance was high. Later on they used a couple of 2000-kw. turbine-driven unipolar generators, but they showed a heat loss of some 30 per cent. Then his nephew, Mr. J. B. Herreshoff, conceived the novel idea of employing a low-voltage alternating-current generator, the output of which was rectified, without voltage transformation, by a properly designed rotary converter. The idea did not at first meet with favor among the engineers of the large electrical manufacturers, but was finally accepted and a good many of these machines are now in use for this type of work.

Mr. **J. B. Herreshoff**, who followed his uncle on the floor, said that by doubling the current density twice the amount of copper will be deposited in a given time. This requires double the voltage and thus four times the power, but has the advantage that the electrolyte is automatically kept warm without the use of steam. Although the power requirement is quadrupled, the cost per pound of copper is only doubled. But the objection to the use of this method in electrolytic copper refining is that the deposits are not so smooth, but are apt to be crystalline, more brittle, and this is often a serious matter in handling the cathodes.

President **C. O. Mailloux** said that the statement that the character of a deposit depends upon the current density is true in the sense understood by the speaker, but that as a general proposition it needs some qualification. As a matter of fact, it is possible to obtain good copper and bad copper at any current density from 10 to as much as 1000 amperes per square foot. He had worked this matter out in 1885, when he had to solve the problem of producing electrotype shells at an extremely rapid rate. Even with a current density of 500 to 1000 amperes per square foot beautiful deposits are obtained, if careful attention is paid to the solution, means of circulation, control of temperature, etc.

Dr. Mailloux finally explained the paradox that with a given amount of electrical energy it is possible at least in theory to deposit any amount of copper. The proof is based on the facts that the e. m. f. required is practically the voltage drop due to resistance only and that the weight of deposit depends only on the ampere-hours. Let a number of ampere-hours pass through a single electrolytic cell, then we will get a certain deposit. Now, let us use four identical cells, arranged in two sets in parallel, each set containing two cells in series, and let the voltage at the terminals of the whole system and the current passing through the whole system have the same values as before. Then the current density is reduced to one-half the former value in each cell. The deposit obtained in the same time is twice the deposit obtained in the former case, while the energy (watt-hours or volts × ampere-hours) is exactly the same as in the former case. Now this multiplication of cells may be carried on in the same way further and further, but a point will finally be reached when, although very large deposits are obtained with the given energy, yet the area of plant required and the interest costs on the large amount of copper tied up would prevent the economical use of any lower densities.

Mr. **Lawrence Addicks**, in speaking on the effect of current density, said that the higher the current density the more rapid must be the circulation in order to keep saturated copper solution close to the cathode, as this is the secret of good deposits. But in the rapidity of circulation the copper refiner is limited by the necessity of keeping the silver and gold slime at the anode, without stirring it up and fouling the cathode. Mr. Addicks also put in a good word for the reciprocating engine driving a direct-current generator as against the turbine, with its alternating-current generator, transformer, rotary converter and booster.

Mr. **C. H. vom Baur** discussed the possibilities of oil engines for electrochemical purposes. Oil from fields recently discovered in Mexico can be sold in New York, he said, for less than 3 cents a gallon, so that such engines can produce a killowatt-hour for 0.45 cent.

Mr. Addicks in closing the discussion pointed out that the oil engine employs a fuel which, compared with coal, is in the hands of a small selling group, and he also questioned whether such internal-combustion engines have the reliability necessary for electrolytic work.

Mr. Longwell said that the gas engine has a great many uses to which it is eminently suited, but in a wholly impartial way he did not think that electrolytic plants were included among these.

Mr. Newbury explained as the reason for selecting very large plants as examples his efforts to show that in such sizes the converter apparatus recommended is really simpler, more reliable, more efficient, and less costly to maintain than the apparently simpler installations consisting of merely prime mover and generator. In sizes of 1000 kw. to 2000 kw. he admitted the turbo-alternator and rotary-converter cannot make a showing against the direct-current generator, provided the electrolytic plant is located near the place of generation.

After the meeting there was a most enjoyable smoker tendered by the American Institute of Electrical Engineers.

## Notes

**Dunn Powdered Coal Burners.**—In connection with the article by Professor G. A. Roush in our January issue it is interesting to note that the Dunn burners have been installed in seven cement plants, four in the East, two in the West, and one in Germany. They are being used by the Carolina Ore Company, at Winston-Salem, N. C., in nodulizing iron ore. An installation that has just been completed for the reduction of nickel and monel metal is giving very promising results. A burner feeding 40 lb. of coal per hour has taken the place of an oil burner consuming 90 gal. of oil per hour, equivalent to 952 lb. of the coal in calorific power giving a saving of almost one-third in heat required, and of still more in cost, since the coal is cheaper than the oil, for this same heating power.

**Electric Steel in England.**—According to a consular report, the first English plant devoted exclusively to the manufacture of electric steel is being erected by the Stobie Steel Co., of Sheffield, on the banks of the Tyne at Dunston near Newcastle. Two furnaces, of 15 and 5-tons capacity, respectively, will be used for melting and refining, and a smaller furnace will be built for producing ferro-alloys. Suitable laboratories will be provided for testing and micrographic purposes. The plant is to be in operation this month.

**Electric Tin Smelting.**—In its issue of January 17, 1914, a prominent American mining paper publishes an article on "Electric Tin Smelting," stating that it is "reproduced from an abstract in the *Mining Journal* from *La Revista Minera y Metalurgica de Madrid*, 1913, based on the experiments carried out by H. Harden in Cornwall and described in the *Elektrotechnische Zeitschrift*. If we add that Mr. Joh. Harden's article appeared originally in METALLURGICAL AND CHEMICAL ENGINEERING in the issue of September, 1911 (Vol. IX, page 453), the record of the travelings of this article through different countries and different languages until its return to New York, some two years later, is complete.

**The discovery of platinum in Germany** is reported by Consul Thomas H. Norton, of Chemnitz. The discovery was made at Wenden, Westphalia, in a district where base metal mines are abundant. Analyses of many borings show the presence of platinum in amounts varying from 0.9 to 1.9 troy ounces per cubic yard of rock. An area of 500 acres has been examined by drilling and found to contain platinum-bearing rock.

# The Present Status of the Wood Turpentine Industry*

BY E. H. FRENCH AND JAMES R. WITHROW

In treating a subject that has as many phases as this one, it will be necessary to discuss briefly an allied industry, namely, that of gum turpentine as distinguished from wood turpentine, in order that the reasons calling for the development of this latter industry may be seen with the proper perspectve.

That the wood turpentine industry is at present at an extremely low ebb is unquestionably true. Nevertheless, it is likewise true that its scientific development is an economic necessity for certain localities, in order that waste may be conserved, that the products from waste replace those from the fast disappearing pine and fir forests and that cut over land may be cleared at a profit instead of at a loss. Therefore, in this instance, as is often the case, necessity compels development.

The fact that thousands of dollars have been expended and lost in the incubation of this industry has been due, in our opinion, to three main causes, any one of which in itself would account for failure; first, the lack of practical scientific engineers experienced in this or analogous fields, second financing for the sale of stock and securities rather than product, and third lack of efficient marketing organization. It must also be borne in mind that, owing to the number of different processes, there was caused a lack of uniformity of product, which naturally tended to increase selling costs. Except to the U. S. Navy little, if any, wood turpentine has been sold on thorough specifications. There has as yet been no real attempt by manufacturers to effect a general standard, although a few years ago the producers of the practically defunct steam process turpentine attempted to standardize their product.

One of the important influences that tended at first toward the development of the industry and later proved extremely detrimental was the speculative nature of the naval stores market. This was made up entirely of gum turpentine and rosin, upon the prices of which the relative wood turpentine values were determined. This market in the past has been subject to violent price changes, a fluctuation of from 30 cents to over $1 per gallon having been experienced, and this was due almost wholly to speculation. Naturally, therefore, during the upward swing of prices an unnatural development occurred, and plants using costly processes and with inefficient management were profitably operated and exploited. It followed, of course, that when the national government, through criminal prosecution, put a stop to excessive speculation, a corresponding reaction occurred, ruining many concerns which required abnormal prices for financial success.

Unreasonably high prices not only encouraged the development of the wood turpentine industry, but also caused an expansion in operations by the gum turpentine manufacturers, so that a larger percentage of trees were boxed, causing overproduction.

### Gum Turpentine

The method of producing oil of turpentine from the resins of coniferous trees consists in cutting a broad, wedge-shaped notch or cup at the base of the tree and removing the bark immediately above the notch for about 18 to 24 inches. The resin exuding from the peeled area runs into the cup at the bottom and is collected from time to time. Each succeeding season the barked area is increased until it reaches about the height of one's head, usually taking five or six years. As many as four "boxes" are thus cut on one tree, depending on its size, permitting only enough of the original bark to remain to prevent the death of the tree.

After collecting sufficient quantity of the resin, it is distilled in a copper still, usually a "fire still," equipped with live steam jet or a water supply. The turpentine thus produced is not carried farther in any refining process, but is ready for the market. The residue in the still is the rosin of commerce and is barreled at the still. The dross obtained by filtering sticks, dirt, etc., from the rosin is in many places being worked into the cheaper grades of rosin. With rosin at an average price, it is generally figured that to make the operation profitable, about 42 cents per gallon must be obtained for the turpentine.

The marketing of the products is done through "factors," as they are called—that is, companies or individuals who contract with the producers for their output, supply them with funds for payrolls, etc., and advances when necessary. These "factors" take the product when produced, but usually have no other connection with the producer. Savannah, Georgia, is the leading naval stores center in the world, and usually Savannah prices are accepted as the standard. Jacksonville and Pensacola, Florida; Brunswick, Georgia, and New Orleans, Louisiana, are also large "factor" centers for this industry.

This method of producing turpentine is generally conceded to give the best turpentine and rosin, but, unless more scientific methods are very widely adopted, the time is fast coming when it will be necessary to supply these products from another source, for present methods of operation are coming to be looked upon as directly antagonistic to all ideas of conservation under American lumbering conditions, as they so weaken the trees that the loss from windfalls is extremely large. In fact, many large lumber companies have given up boxing for this reason, and also because they feel that the growth of the young tree is retarded.

Modifications of the old "boxing" methods are being used in some places. Metal cups are substituted for the box cut in the base of the tree, and it is claimed that the loss from windfalls is considerably reduced by some of these modern improvements. At least one large Southern lumber company is at present experimenting on 5000-acre units in order to determine definitely, if possible, the merits of these new cups and other modifications as to yield and influence on windfalls, and also to decide the effect "boxing" may have on finished lumber.

### Wood Turpentine

Wood turpentine came into commercial notice about the year 1900. The name was, and is, applied to the product obtained from dead and down timber, a waste product called "lightwood." The live or green wood is not so suitable for this manufacture, owing to the moisture content and also to the fact that the bark still remains. Stumps, however, are very valuable, as they contain a much larger proportion of resins than "lightwood." Nevertheless, the cost per cord of stump wood is considerably more, as the stumps usually require the additional expense of removal by explosives. The cost per cord of "lightwood" at the works will run from $2.00 to $3.00, making, however, no allowance for its value as waste, while stump wood will vary from $3.50 to $5.00 per cord, the price depending on acre stumpage and hauling distances. The manufacture may be divided into five general processes—steam process, solvent process, alkali process, bath process and distillation process.

Before entering into a description of these various methods, we desire to emphasize the statement that the manufacture of wood turpentine necessarily will become of far-reaching importance in the future. This is for the reasons that it is utilizing an absolutely waste product and is at the same time clearing cut-over lands and rendering them fit for occupancy.

---

*A paper read before the American Institute of Chemical Engineers.

We wish also to emphasize the statement already made that many past failures were due to the unreasonable speculative condition of the markets. Abnormally high prices of naval stores induced promoters and unscrupulous persons to capitalize their concerns on the earning capacity during this period, thereby making them "stock jobbing" propositions rather than legitimate manufacturing institutions. This kind of financing, while apparently expanding the industry, really retarded development, as the energies of the management were expended primarily at the office end at the expense of the manufacturing organization.

We have seen from time to time figures of promoters regarding yields and manufacturing costs of the different processes which are not in accord with the results obtained from continuous operation. It may not be entirely without value, therefore, to cite some comparative yields and operation costs in the different processes. This is especially true, since there does not appear to be any published data of this nature.

While the records themselves of individual plants would be interesting, such records are often misleading, and in view of actual or possible competition the location of plants themselves must be withheld. In submitting data as to yields, values and productive costs we have compiled them mainly from the actual results obtained during continued operation of a number of large plants. As so many elements making up these figures are variable, owing to location, construction and raw material, our endeavor has been to average them so that a comprehensive idea may be had as to actual results obtained commercially.

*Steam Process.*—This process was the first to be extensively placed in commercial operation and is very simple in its construction and handling, consisting merely of hogging the wood and placing it in a steel cylinder, usually holding about a cord, distillation being carried on with live steam and under varying pressure. However, there was probably little difference in results whether a maximum of five pounds or twenty pounds pressure was used. Distillation was carried forward until oils ceased to be obtained in quantity.

It should be borne in mind that there is a decided variance in the resinous content of wood, therefore, it was quite possible to make a selection that would run as high as 30 gal. of turpentine to the cord. We believe the following figures, however, based on a cord of long leaf yellow pine lightwood, weighing 3500 pounds, would be the average:

| | |
|---|---|
| Turpentine, 9½ gals. at 35 cents | $3.32 |
| Pine oil, 3 gals. at 35 cents | 1.05 |
| Total value of products | $4.37 |

Production cost per cord:

*Production Cost per Cord.*

| | |
|---|---|
| Wood | $3.00 |
| Labor | 1.00 |
| Barrels | 0.42 |
| Freight (approximate) | 0.20 |
| Selling commission | 0.25 |
| | $4.87 |

The fuel cost is only the labor of handling the treated chips. However, there is no allowance made for the office, upkeep, depreciation insurance, etc. Therefore, it can be seen that the steam process necessarily, in order to be profitable, demands a market price considerably in advance of the present markets.

The price of wood turpentine is always a few cents per gallon under that of gum turpentine. The quality of the product produced by the steam process, however, is excellent. Our opinion is, nevertheless, that at least 50 cents per gallon is necessary as a minimum for successful operation.

*Solvent Process.*—In the early development of this process the wood was subjected to the old steam treatment and subsequently treated with carbon-disulphide for the recovery of rosin. The loss of solvent rendered it impractical. In the next stage of development the wood was hogged and placed in digesters for the recovery of turpentine and pine oil. Then the solvent (a low grade of gasoline) was added, live steam was applied, recovering some turpentine, pine oil and solvent by distillation, and the dissolved rosin drawn off, its volatile matter being recovered by distillation.

This has been improved, subsequently, in some instances by omitting preliminary steaming, adding solvent direct and recovering this with the turpentine and pine oil by live steam in the primary distillation, obtaining rosin alone when the still is drawn. The rosin, however, is soft, and difficulty has been experienced in obtaining a hard product, but this is overcome by subsequent treatment. In either method, a considerable loss of solvent is always entailed, varying from 17 to 30 gal. per cord.

The approximate yields and operating costs per cord are as follows:

| | |
|---|---|
| Turpentine, 9½ gals., at 35 cents | $3.32 |
| Rosin, 400 lbs., at $4.00 per 280 lbs | 5.72 |
| Pine oil, 3 gals. at 35 cents | 1.05 |
| Total value of products | $10.09 |

*Production Costs per Cord.*

| | |
|---|---|
| Wood | $3.00 |
| Labor | 2.50 |
| Loss in solvent at 15 cents (17 gals.) | 2.55 |
| Barrels | 0.42 |
| Rosin barrels | 0.25 |
| Selling costs | 0.50 |
| Freight | 0.75 |
| Total | $9.97 |

Again the actual fuel cost in this process is negligible as use is made of the "treated chips." No allowance is made here for insurance, upkeep, overhead and interest charges, refining costs or depreciation; therefore, it is plainly evident that at present market prices, at least until improvement is made in yields or in minimizing costs, there is not sufficient margin for successful operation.

However, it is quite possible that by using the "treated chips" for paper pulp manufacture that this process will be made of commercial value. The operation in this case would have to be maintained on an enormous scale in order to supply treated chips for a pulp plant unit of an economic size. A plant using this solvent system and built on a very elaborate scale was in operation in Southeastern Georgia, and, despite the most advantageous financial backing, was unable to operate profitably on a weakened market, and is now in the hands of receivers.

This citation alone probably would not necessarily condemn the process, but as several smaller plants are either in like position or shut down, it indicates the necessity of research or development if ultimate success is to be attained. As with the steam process, many claims of higher yields than we have above credited are made by interested parties, but these claims are still subject to substantiation.

*Alkali Process.*—This process is essentially one to be applied to the alkali processes for manufacturing paper pulp from resinous woods with the recovery of turpentine and rosin and at the same time improving the quality of the pulp and promoting ease of manufacture. The process is well covered by patents.

The basis upon which this method rests is the fact that the sodium hydroxide saponifies the resins in the wood and the sodium resinate thus formed may be separated from the spent soda pulp liquor by temperature regulation. The wood is handled in the same manner as in soda pulp manufacture, except that after digestion the spent liquor is cooled for the separation of sodium resinate before this liquor proceeds to the evaporators. This product has been so purified and refined commercially, as to produce a good quality of paper size. The resinate may if desired be manufactured into rosin by acid treatment, or destructively distilled, obtaining rosin oils. The turpentine is recovered from the digester blow-off during the digestion operation.

This process is apparently theoretically sound, but requires the outlay of capital to develop thoroughly the mechanical details. Fifty to seventy thousand dollars were expended in one case to demonstrate its commercial possibilities, and some results were obtained. However, the enterprise has not been financially successful and the plant has been dismantled, a fact which may be due to faulty engineering or other causes, and even though the process appears enticing from a theoretical viewpoint the fact remains that the trial was not successful, and there is no process of this kind in actual operation.

Nevertheless, it is our opinion that eventually it will be of commercial importance, and ultimately the combination of the two industries, paper pulp and turpentine-rosin recovery, thus utilizing resinous wood, will be successful. Unusual yields of turpentine are claimed by a Florida plant using an alkali bath, but satisfactory arrangements have not yet been made regarding rosin recovery.

*Bath Process.*—This process must not be confounded with the recently suggested process using a bath or envelope of oil external to the oven for the purpose of heating the same. This external bath process has not been long enough in operation to demonstrate its future, and it will be interesting to note if certain fundamental operation difficulties can be overcome.

By bath process we refer to the process commercially called the bath process which has been in operation for some time, and in which the bath is within the oven, or retort, in contact with the wood itself. Three plants using this method have been built, the first in North Carolina, which has been dismantled; the others at Mt. Pleasant, Ga., and Jacksonville, Fla., which have not been successful under low market conditions, and both of which have gone into receivers' hands within the last few months.

The process itself was divided into two separate general operations. First, the recovery of turpentine and pine oil, or, as styled, "sweet spirits," and subsequently the destructive distillation of the wood itself, although this second operation was not contemplated in the original process.

The operation has a decided advantage over the solvent and steam processes in that it does not require the "hogging" of the wood.

The general construction used in this first operation consists of steel cylinders at Mt. Pleasant, and concrete ovens at the Jacksonville plant, each holding five to nine, 1 to 2-cord steel cars, similar in construction to those in common use in hardwood distillation; thus each oven holds about nine cords of wood. Placed at the side of the oven is a heater equipped with a large cast iron worm connected to the bottom of the oven. To the rear of the heater is placed a large steel or concrete reservoir connected by cast iron pipe to the top of the oven and also to rotary pumps, which in turn are connected to the heater pipes.

The loaded cars are placed in the oven and melted rosin or pitch is run into the reservoir and circulated by the pumps through the heater and the bottom oven connected. This pitch, after filling the oven, overflows into the reservoir and is thus continually circulated through the heater and oven, thereby vaporizing the volatile resinous bodies and without dissociating the wood fibre. The turpentine and oil vapors are carried through a "vapor" chamber where the high boiling liquids that are mechanically carried by the vapor are separated, the vapor continuing to an ordinary tubular condenser, where the crude "sweet spirits" are obtained. Afterward the "sweet spirits" are refined, the products being turpentine, pine oil and a tarry residue. The time required to "treat" a charge varies in the plants mentioned from seven to ten hours, and the product obtained is of high quality, though not so good as steam process turpentine.

At first sight it would appear that in this process the rosin from the wood treated would gradually increase the volume of the bath and rosin be thus manufactured. The reverse of this, however, is the case, as a very serious loss of bath is actually realized. This is, in fact, a serious drawback to the process, and is probably due to the formation of volatile rosin oils when the liquid bath encounters the high temperature of the heater. These rosin oils are volatilized and pass into the "crude spirits" and are lost in the refining residue, as only from 65 to 70 per cent of the spirit is received as turpentine and pine oil. By proper arrangement this difficulty could have been avoided.

This process is also seriously handicapped by the fuel consumption of the heaters and the heavy upkeep for heater pipes and pumps. Nevertheless, with proper design, operation costs would have been much reduced from that actually experienced.

After refining, the results from this "sweet process" could be averaged as follows:

| | |
|---|---|
| Turpentine, 7½ gals. at 35 cents | $2.62 |
| Pine oil, 2½ gals. at 35 cents | 0.87 |
| | $3.49 |

After the charge is withdrawn in this first operation the "treated" wood is placed in ovens similar to those used in the hard wood industry and there subjected to destructive distillation. The results obtained here are very important, as a good market has been created for these products. An average of from 68 to 70 gal. of oils is obtained, together with a like volume of "acid water," the latter a "waste," although its utilization was accomplished just prior to the receivership of one of the mentioned companies. In addition there remain in the cars approximately 900 lb. of charcoal, and there is produced about 10,000 ft. of non-condensible gas per cord which is of fuel value.

This crude distillate above mentioned is called "destructive distillate" or "D. D. product" to distinguish it from the product derived from the resins called "sweet spirits." On refining there are obtained the following products per cord:

| | |
|---|---|
| Tar, 41 gals. at 8 cents | $3.28 |
| Light oil, 6.8 gals. at 12 cents | 0.81 |
| Heavy oil, 10 gals. at 12 cents | 1.20 |
| Charcoal, 36 bushels at 7½ cents | 2.70 |
| From "Sweet Process" | 3.49 |
| Total value of products | $11.48 |

*Costs of Production per Cord.*

| | |
|---|---|
| Wood | $3.00 |
| Fuel | 3.25 |
| Labor | 2.75 |
| Cooperage | 1.00 |
| Selling costs | 0.60 |
| Freights (approximate) | 0.75 |
| | $11.35 |

Again it can be seen that this process handled as it has been in the past cannot be operated successfully on a low market, as no allowances have been made for upkeep, insurance, interest charges, refining costs, management or depreciation. Although the loss in bath is partially made up by the pitch obtained, it can be seen from these costs that improvement must be had before this process can exist during low market conditions. It is not to be inferred, however, that the principles upon which the process is based are entirely faulty. The reasons for its failure appeared to be lack of knowledge as to the chemical nature of the products and troubles consequent to improper construction and operation.

As is common with approaching dissolution, strenuous efforts at improvement were made in this process, and, despite well known prior failures, experiments were completed and operation commenced for the utilization of the waste "acid water" just before the closing of one of the plants. The results proved interesting and promised excellent recovery, as the products recovered, including acetate of lime and wood alcohol, represented a net gain of well over $1.50 per cord.

*Distillation Process.*—As the wood turpentine industry now stands, the destructive distillation process apparently has the best chance of commercial success, as it is not only more simple in construction and operation, but yields more in volume of products. Chemical and engineering skill, nevertheless, are necessary for this success.

The distillation process may be subdivided into three divisions. First, that division analogous to hard wood distillation. This method in its primary operation is very similar in equipment and design to the usual hard wood distillation plant, the wood being placed in steel cars and run into ovens. The products derived from the resins and those from the dissociated wood are collected together, and separation is made during refining, although some attempt has been made at fractional distillation in this primary stage. This method gives a much inferior grade of turpentine, etc., owing to the commercial difficulty of eliminating the pyroligneous bodies, and the product will not answer to the permanganate test, which indicates pyroligneous matter. The tar produced in this operation is usually resinous and for some uses therefore objectionable.

The second division is merely a modification of this process, the ovens being in duplicate, and distillation for the resinous bodies being carried out in one oven, so designed or "set" that the temperature can be maintained approximately uniform. After the resinous bodies have been obtained the "treated wood" is withdrawn and placed in a second oven, and in this oven the distillation is carried at a higher temperature for the destructive distillation of the wood itself.

The third division is that using concrete ovens containing 12-inch heater pipes, running the length of the ovens. These ovens have Dutch-oven connections and the flue gases travel through these pipes, and it is claimed that temperature regulation is more easily accomplished.

In all these processes the products obtained are the same, except so far as the degree of purity is concerned.

The first distillate, or that from the resins in these methods will run on an average 22 to 24 gal. of "sweet spirits." This on refining will give from 50 to 60 per cent, or from 12 to 14 gal. of marketable turpentine, and from 9 to 10 per cent of pine oil, or from 2 to 2½ gal., and also 100 lb. of a very resinous pitch.

The destructive products are the same as those from the "bath process." Thus it can be seen that the gross total in this operation should be materially higher than in the other processes, while the operating expense is very much lower. This, including wood, upkeep and in fact all expense, should not, under proper design, construction and management run over $9.00 to the cord.

The particular objection raised against the destructive distillation process is that the products are difficult to market, and this has been true to a certain extent in the past, but when it is considered that many of these bodies were new to the trade, this condition cannot be wondered at, and at present the marketing is not more difficult than products of other processes. In fact, just now there is an unusual demand for these products.

### Markets

It may perhaps be of interest to call attention to the various developed markets for the D. D. products, for we all realize that the marketing of products is at least equal in importance to the manufacture; and this industry shows many instances where comparative merit of process and operation was wholly lost by inferior marketing facilities, and, on the other, hand, instances in which unsound operation was maintained for considerable time by a remarkably efficient selling organization. The latter cases, while losing ventures to those financially interested, have no doubt succeeded in creating a growing demand for the products as indicated by the prices obtained now for them with many plants closed down.

At the time this article is written tar could easily be sold for 12 cents per gallon, as compared to the 8 cents allowed in the cost data in the article, but which should be considered maximum, as the future, undoubtedly, will increase supplies so as to bring these prices back to a more nearly normal condition.

This fact, however, does show that a demand has been created that did not exist prior to the quite recent establishment of plants of this nature. Perhaps this condition is more clearly evidenced in the heavy D. D. oil, for which 22 cents per gallon is being obtained. The tar demand had in a measure been previously supplied by that known as "kiln tar," made at works using the kiln system for charcoal manufacture from resinous woods.

The product mentioned as D. D. light oil is at present most difficult to market profitably—this is on the market in this form and is used to some extent by manufacturers of disinfectants. However, it has been fractionally distilled and has been used locally as a substitute for gasoline for use in engines and has proven itself to be more efficient than gasoline. The comparatively small amount of this product makes its use in this manner merely of local interest, but it indicates a real value of the product.

The Heavy D. D. Oil has been in consistent and increasing demand, particularly in the paint industry and notably for shingle stains, and also for the manufacture of tar oils, for which there is a large foreign demand. The necessity of an energetic market agency was in one case well illustrated within the past year with this product. One large concern was offering this product for 5 cents per gallon, finding it impossible to market, having nearly 100,000 gal. in storage, while at the same time another company was unable to supply its customers at 18 cents per gallon. Of course, the latter considered the purchase from the former, but feared future competition, in case, as seemed dangerously probable, the former concern should learn of their customers.

The pitch produced in the distillation process and distinguished from the tar has a firm market demand from ship chandlers and also is sold for uses, such as coating silos, rendering them impervious to moisture.

The tar, of course, has its established uses, with rope manufacturers as well as with paint producers, while the charcoal consumption, particularly in the south, is very steady both for domestic use and manufacturing. Of the number of suggested specialties based on the use of tars and oils, doubtless a few will ultimately contribute a steady demand for a portion of these products.

### Cost of Installation

The various processes have in most instances exceeded reasonable installation costs. Undoubtedly the same is true in any newly established industry, and more particularly in cases where, as pointed out in this one, prices could be obtained that were out of all proportion to production costs.

Entire equipment of a steam process plant should come well within $750.00 per cord capacity, while the solvent process complete should be approximately $2,000.00 per cord; this also should be approximately that of the bath system, while the destructive distillation method ought to be very close to $1,500. In making these general estimates neither working capital nor purchase of timber or stumpage is considered.

### Conclusion

When your attention is brought to the fact that the destructive distillation plants alone have been able to survive recent price depression, it is reasonable to conclude that, in the present state of the art, this method has inherent advantages. Nevertheless, in this type of process, there is room for much improvement, particularly in refining and the utilization of waste products ignored in the past. Constructive chemical engineering apparently has, in this industry, opportunity to create an unusually profitable business, provided it utilizes the unfortunate mistakes of the past by combining parts of the various processes.

It is not to be inferred from this article that recommendations are made for the encouragement of any particular process, the motive is merely to outline present conditions, or, broadly, to show cause and effect, and also to show, if possible, that many elements are as necessary in this industry as in any other to attain success. Statements have been made to the effect that failures in most instances were due to lack of real engineering skill, and this is partly true, but lack of skill is not wholly accountable for even the engineering failures, for no amount of theoretical enginering skill can replace the knowledge acquired from continued intimate contact with the going operation.

Neither does this statement take into consideration the marketing organization, which is also an essential and is always confronted with the general economic situation, which does not affect directly the operation.

It can be seen from this outline of the industry that its very existence was primarily due to an unnatural market condition, and as the field for profit and exploitation was so enormous it can hardly be wondered at that unusual activity was had in its promotion.

---

**Butte and Superior** made a new record in milling efficiency in November, 1913, when the concentrates averaged 50.58% zinc and the recovery over 90%. The total production for the month was 10,995 tons of concentrates containing 11,123,000 pounds of zinc.

**Plans and some details** of the new Massachusetts Institute of Technology are announced in the November, 1913, issue of the *Technology Review*: "From the waterside it will present the appearance of a great white city of majestic proportions, with the long vistas of its facades broken by suitable intervals, and relieved by the foliage of shrubbery and trees. The interest of the spectator will center in the broad court extending back a sixth of a mile from the river and leading by terraces to the great colonnaded portico of the central building of the group." The educational portion will be a connected group of buildings three and four stories in height. The arrangement will be flexible to provide for future expansion of the departments.

## Mechanical Refrigeration—I

### Choice of Refrigerants

BY H. J. MACINTIRE

Mechanical refrigeration is a process of cooling by means of a reversed steam-engine cycle. In this cycle external work is done on some agent either by heating a solution directly with steam or by some other means or by compressing the vapor with a metallic or fluid piston. Heat is added to the working fluid at a lower temperature, and is abstracted at the higher temperature—mechanical energy having been supplied between these two processes of sufficient amount to make it possible. In mechanical refrigeration, then, a refrigerant —the special term used in referring to the working agent in this particular thermo-dynamic cycle—has to be employed.

There are certain essentials in mechanical cooling, as far as the working medium is concerned, which usually must be complied with. For instance, the volume of the refrigerant must be reasonably small, otherwise the refrigerating machines become bulky and expensive. The kind of refrigerant chosen must be such as will give readily the desired temperature; it must be cheap, if a new supply is used at the end of each cycle, or it must be of stable composition, if the refrigerant is used continually. With these factors in mind, an analysis of the possible refrigerants will now be made, and the advantages of the more common ones will be considered.

One of the first of the practical refrigerants to be used was *air*. It is without cost, is available everywhere and is harmless if allowed to exhaust or leak out of the system. Yet it is now found in but a few installations and mostly in a modified form called the "dense air machine." The reason for the abandoning of air is because of its low heat capacity, as will be clearly seen on a consideration of a typical example. A pound of air at — 100 deg. Fahr. might be allowed to come into metal contact with brine or other substance whose temperature it is desired to lower.

If the air is allowed to be raised to + 30 deg. Fahr., or a total heating of the air by 130 deg. Fahr., the possible amount of refrigeration would be, per pound, $130 \times 0.24 = 31.2$ B.t.u., and the volume of this pound of air at atmospheric pressure would be approximately 12.4 cu. ft.

Should a closed cycle be employed (the air being used over and over) the volume of 1 lb. of the air leaving the cooling coils may be one-quarter or one-fifth of the amount above, depending on the cooling pressure used. In the last case refrigeration is obtained by the so-called "dense air" cycle. However, even the dense air refrigerating machine is bulky, inefficient, and troublesome to operate and except for unusual circumstances machines using air as a refrigerant are obsolete.

Let us now consider the case of easily condensed gases, i.e., the vapors, and allow the liquid refrigerant to pass into the cooling coils. In order to evaporate this liquid, heat has to be added, and in the evaporation an amount of heat equal to the latent heat of vaporization has to be taken away from the surrounding bodies—the latter thus being cooled by a like amount. The amount of this latent heat, in heat units, depends on the substance and somewhat on the temperature of vaporization, and may be 160 B.t.u. per pound for ether, 360 B.t.u. for alcohol, 550 B.t.u. for ammonia, and 1000 B.t.u. for water vapor. Even in the case of ether the amount of possible cooling per pound of refrigerant is above five times that possible in the case of air, whereas it is only one-sixth of that theoretically possible when using water vapor.

From what has been said it is clear that a very wide range of substances suitable for refrigerants are at hand, and yet the number actually used is small—less than a half dozen, namely, water vapor, sulphur dioxide, carbon dioxide, and ammonia. The method of elimination, and the choice of a possible refrigerant, is suggested by what follows under the topics of cost, chemical and physical properties.

### Cost

The cost of the four refrigerants chosen for our analysis—water vapor, sulphur dioxide, carbon dioxide, and ammonia—is, except for the first one, much too great to allow them to be used in any way except continuously. Therefore, a closed cycle is necessary, and when the working medium has performed its function of cooling it is compressed again, and made to repeat the operation. Water, then, as it is practically without cost, has a great advantage over the other three and, other things being equal, it would be the most acceptable substance for a working medium. Unfortunately the cost is not the only consideration.

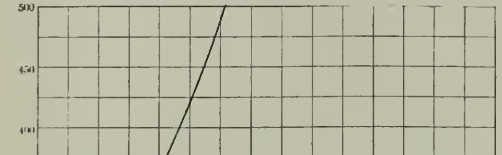


FIG. 1—PRESSURE-TEMPERATURE CURVES FOR DIFFERENT REFRIGERANTS

Table 1—Liquid Refrigerant at Expansion Valve = 68° F.

| | 1<br>Latent Heat at —4° F. ($L_1$) | 2<br>Heat of the Liquid at 68 F. (q) | 3<br>Heat of the Liquid at —4° F. ($q_1$) | 4<br>Refrigeration Theoretically Possible [$L_1 + q_1 - q$] | 5<br>Ratio of Columns, 4/1 | 6<br>Specific Volume at —4° F. | 7<br>Volume in Cubic Feet at —4° F. for 100,000 B.t.u. of Refrigeration. | 8<br>Column 7, with $CO_2$ Expressed as Unity. | 9<br>Approximate Condenser Pressure. | 10<br>Boiling Pressure, Corresponding to —4° F. |
|---|---|---|---|---|---|---|---|---|---|---|
| Sulphur Dioxide, $SO_2$ ...... | 172.66 | 11.92 | —11.07 | 149.67 | 86.7 | 8.22 | 5,490 | 13.42 | 48 | 9.25 |
| Carbon Dioxide, $CO_2$ ...... | 118.87 | 24.2 | —17.87 | 76.8 | 64.6 | 0.313 | 408 | 1.00 | 830 | 289 |
| Ammonia, $NH_3$ ..... | 575.3 | 39.9 | —37.9 | 497.5 | 86.5 | 10.08 | 2,025 | 4.95 | 130 | 27.13 |
| Water Vapor, $H_2O$ ...... ...... | 1,094.4 | 36.1 | —36 | 1022.3 | 93.5 | 16,750 | 1,635,000 | 4,010 | 0.339 | 0.017 |

### Chemical Properties

The chemical properties of the refrigerant are important as far as concerns the corroding action on metal, safety, and ability to withstand disintegration. Anhydrous sulphur dioxide has been found to attack iron at about 205 deg. Fahr., but this is a temperature which is never reached under normal operation of the compressor. Ammonia corrodes copper and copper alloys, so that this metal has to be entirely eliminated from the ammonia circuit. As far as their action on animal life is concerned (water vapor excepted) the refrigerants under consideration are almost equally dangerous. Sulphur dioxide and ammonia are easily detected by their smell, but carbon dioxide (when pure) is odorless and as much as 1 per cent or two per cent may be present in the air without discomfort. Ammonia has been found to burn at 900 deg. Fahr., and is also perhaps the least stable of the four compounds, hence successive use in the refrigerating system tends toward a slow disintegration.

### Physical Properties

So far this analysis of the refrigerants (except for the cheapness and safety of water vapor) gives no reason for particular preference of any one over another and it remains for a critical consideration of the physical properties to determine what refrigerants are of value in given cases and which are the most desirable under those particular conditions. The physical properties may be compared by considering tables of these vapors in the condition of saturation. Table I and Fig. 1 assemble this data for the several refrigerating media which we are examining.

Referring to Table I: Column 1 gives the latent heat of vaporization for the four refrigerants, assuming a uniform boiling temperature of these of —4 deg. Fahr., this temperature being maintained constant by keeping the pressure in the cooling coils uniform and equal to the amount given in column 10. Columns 2 and 3 contain the values for the heat of the liquid at 68 deg. Fahr and —4 deg. Fahr. In this regard it is assumed that the cooling water available is of such a temperature that the refrigerant may be cooled to 68 deg. Fahr. The corresponding condenser pressure is given in column 9 as well as in the figure.

Column 4, obtained by subtracting the sum of 2 and 3 from 1, gives the net theoretical amount of refrigeration in B.t.u. per pound of the refrigerant at the operating conditions. It should be clear that the temperature of the liquid refrigerant as it leaves the condenser has a decided influence on the values in 4, as the liquid has to be cooled to the temperature at which refrigeration takes place (here —4 deg. Fahr.) before any useful refrigerating work may result. This cooling is done at the partial evaporation of the refrigerant, and the net result is a decreased value for the possible refrigeration per pound of the medium. The desirability of using cool condensing water in the condenser is apparent, although carbon dioxide only seems to be affected seriously by this, as shown in column 5, which gives a percentage ratio of columns 4 and 1.

As a closed cycle has to be used, the vapor in the refrigerating coils has to be compressed and returned to the condenser in order to obtain a liquid again. The usual method of so doing is to pass this vapor into a compressor, similar in design to an air compressor. The capacity of the refrigerating plant will depend on the piston displacement of the compressor and the volume of 1 lb. (the specific volume) of the refrigerant, the ratio of the two being the number of pounds of the refrigerant compressed and condensed per unit time. Column 7 gives the theoretical displacement in cubic feet of such a compressor for 100,000 B.t.u. of refrigeration and column 8 repeats simply the last figures but with carbon dioxide expressed as unity. Assuming the same rotary speed, the compressor using sulphur dioxide would have to be 13.42 times the size required for carbon dioxide and with ammonia 4.95 times, whereas the value for water vapor is absurdly large.

Referring to columns 8 and 9 it is seen that water vapor is out of the question when used in a reciprocating compressor because of the great volume of the vapor accompanied by the extremely low pressure. Sulphur dioxide has a conveniently low condenser pressure even with condenser water of 100 deg. Fahr. or more, which makes it very useful in the tropics, especially as its efficiency does not decrease greatly—a fact which may be made clear by working out column 5 for this temperature. Its slight pressures allow light construction and enable the machine to be made portable if desired. The size of the machine has to be considerably greater than for ammonia or carbon dioxide. The latter requires a much smaller compressor, but the working pressures are excessive. The cylinder and piping frequently have a working pressure of 900 lb. to 1000 lb. or more; and the leakage loss becomes large as a rule. Low refrigerating temperatures, however, are easily obtained.

In America from 85 per cent to 90 per cent of the total mechanical refrigeration is done by using ammonia as the refrigerant. The reasons for this are to be found in the moderate pressures encountered, its efficiency with condensing water of from 70 deg. Fahr. to 100 deg. Fahr., its medium piston displacement, as shown in column 8, and the ease with which the more usual refrigerating temperatures may be reached. Some space, as far as the compressor is concerned, could be saved by using the carbon dioxide compressor and for this reason as well as because slight leaks are not so noxious or harmful it is commonly found in marine and hotel use. For most industrial work, however, for the reasons given, ammonia as the refrigerant is much to be preferred.

University of Washington, Seattle, Wash.

---

The **Third International Congress of Tropical Agriculture** will be held at the Imperial Institute, South Kensington, London, S. W., from June 23 to 30, 1914. The following subjects, among others, will de discussed: technical education and research in tropical agriculture, labor organization and supply in tropical countries, scientific problems of rubber production, methods of developing cotton cultivation in new countries, problems of fiber production, the cultivation and production of rubber, cotton and fibers, cereals and other foodstuffs; tobacco, tea, cocoanuts, etc. The subscription for membership in the congress will be £1. All correspondence is to be addressed to the Organizing Secretaries, Third International Congress of Tropical Agriculture, Imperial Institute, London S. W. The International Rubber and Cotton Exhibitions will be held simultaneously.

---

## A New Design of Filter Press*

BY ALFRED BURGER

Before describing the new filter press, I intend to give a short survey of the developments in the construction of pressure filters for filtering and washing purposes, and to point out certain lines along which improvements have been made.

If we look back a few decades it seems as though the activities in this branch of chemical engineering had come to a temporary stop with the general introduction of the chamber filter press. This machine had so many advantages that it rapidly found its way into practically every chemical factory and is still in general use to-day. It is a strongly built, reliable and practically fool-proof machine and does do the work for which it is built, though in fact badly, especially since we know that better results are obtainable.

For large-scale operations, however, the chamber filter press had its limitation. Filling and washing took a long time and consequently too many machines were required for handling the slush, and the cost for labor ran up very high. For this reason many plants stuck to decantation or table washing, finishing with a squeeze press. Others which were more progressive tried filtering and washing in the press, but had to give it up.

Judging from the numerous attempts subsequently made to find a cheaper and more convenient way of discharging the solid matter, it appears that the separating and putting together again of the many plates and frames after each cycle plus the cost of labor involved were considered the chief disadvantages of the chamber filter press.

In trying to overcome these drawbacks it was soon found that the chamber filter press did not lend itself very well to such improvements. The only way in which the solid matter can be removed without separating the filter members is by sluicing. This method, though it has proved very successful in some cases, is but a compromise between the old way and something better that was yet to come. Besides, sluicing is only feasible if the solid matter is worthless.

Better results in this endeavor were to be expected from another kind of filter, the leaf type, which was then already in use, though in a primitive form and chiefly for clarifying purposes. It seems as though the inventors of this latter type did not have an adequate conception of the filtering problems confronting engineers in certain chemical and metallurgical fields. Nothing was done by them toward making the apparatus more useful, enclosing the leaves in a suitable shell which would permit an easy removal of the cakes.

The proposition of improving it in this direction was taken up some years later out West, and undoubtedly the great opportunity there revealed has been an active stimulus to the inventors of two types of leaf pressure filters perfected in recent years.

These two are giving very satisfactory results indeed, especially that type of which a model has been exhibited at a previous meeting of the Institute. Yet, if we compare the working of such a modern leaf-type filter with an ordinary chamber press, we find that the superiority of the former is due not to the mechanical discharging but to the greater washing efficiency. Thus the time required for separating the plates and frames and closing them up again at the end of each cycle seems, after all, not to be such a disadvantage as had been represented. The discharging feature, as will be demonstrated later, is in fact a secondary matter.

Besides these successful attempts to solve the problem of discharging the solid matter in a more satisfactory way than is possible in a chamber press, other lines of improvements have recently been taken up with the view of constructing a filter press in which the filtration is followed by a squeezing of the cakes mechanically and to effect filtration at a much higher pressure. But in my judgment no great advantage will be derived from this direction. Owing to the constructional difficulties to be surmounted and to complications of such machines their use will be limited, while filtration under much higher pressure is no more effective.

---

*A paper read at the New York convention of the American Institute of Chemical Engineers.

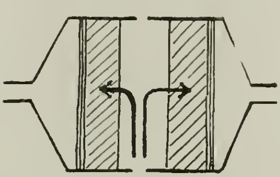


FIG. 1—PRINCIPLE OF WATER PENETRATING THE CAKE IN THE SAME DIRECTION AS THE SOLUTION

Some years ago the writer became familiar with a process of which the filtration of the slush constitutes one of the most important operations, and as the results obtained in the filter presses employed seemed to indicate ample room for improvements, I subsequently and incidentally gave some attention to filter press matters. It seemed to me that not so much the time and labor involved for separating and putting together again the plates and frames, but rather the low washing efficiency of the chamber press was the feature most deserving of correction.

When occasionally filtering the same material through a filter funnel in the laboratory it surprised me that the liquor ran so nicely through the cake, and in proportion much less water was needed for washing the residue free from soluble matter than the big filter press required working with 50 lb. pressure. This observation led me to apply the same washing principle to a chamber filter press which consists of letting the water penetrate the cake in the same direction as the solution. Fig. 1 illustrates this. The cylindrical parts of the two filter funnels facing each other resemble a section through a chamber in a filter press having an opening at the bottom and top. Two distinct cakes are formed which are washed from inside.

To what reason the bad washing in the ordinary chamber press is due has been described before, but let me add, the reversing of the current is not alone responsible for the bad results obtained. Cakes which I have seen seemed to indicate that the inefficient washing, especially in case of slimy solids, is due to a great extent to the uneven filtering soon after fresh blankets have been put in the press. The cakes that begin to form on the wash plate sides are, owing to the continuous good condition of these blankets, considerably denser. The very first deposit is often a relatively hard layer which on reversing the current for washing purposes cracks. Cakes occasionally examined always showed this cracking distinctly (Fig. 2) and a separate testing of the different layers revealed plainly how the water had penetrated the cakes. The hard brittle crust in one instance contained about 6 per cent, the soft central part 0.4 per cent and the left layer 1.2 per cent of soluble matter not washed out.

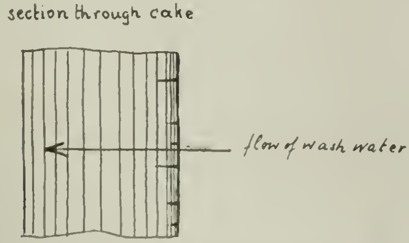


FIG. 2—CRACKING OF CAKES

What I have termed a new filter press is the direct-flow principle, as illustrated in Fig. 1, applied to a chamber filter press of very simple construction. The method of operation is still simpler. Fig. 3 shows a cut through the stationary head and first chamber with pipe connections. The liquid-solid enters from the bottom channel with valve *O* open. As soon as the material begins to overflow, *O* is shut. Filtration starts and is continued until sufficient cake has formed to leave but a space in the center of ½ to ¼ in. Water is then switched on, and after washing has been completed the excess is withdrawn by means of compressed air introduced from the top. Air is then blown through the cakes for a short while when the press is opened and the cakes discharged. Of course, the method just described is not sufficient to insure good results. Certain constructional details are absolutely essential, as otherwise trouble will arise causing complete failure. Now, rather than describing those details I prefer to give a few figures showing the work done by presses in actual operation. Thus I think it will be better appreciated what these improvements amount to.

For filtering and washing an aluminium hydrate precipitate it used to take six hours in the regular chamber press for washing the cakes free from the solution, while with the press of my design one hour is now required. In case of a prussia-blue, washing was reduced from twelve hours to two. A carbonate of lime residue was washed free from solution in less than one-third the time a Dehne press required, and the amount of water needed for doing it was reduced to one-third.

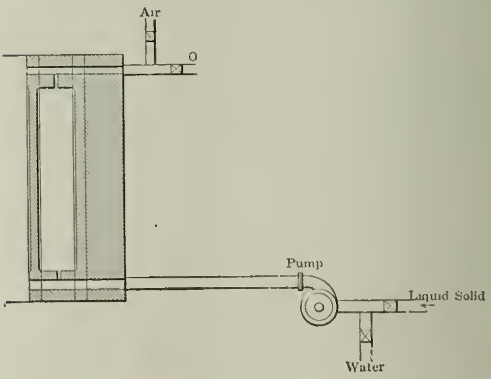


FIG. 3—FILTER PRESS BASED ON DIRECT-FLOW PRINCIPLE

The excellent results obtained induced me to file application for patent for this device. In looking over patent specifications as to improvements on chamber presses I was somewhat surprised to find that apparently nobody before fully realized the great advantages to be gained by this very simple mode of filtering and its general application. I want to emphasize that good results are only obtainable if filtering and washing is carried on without interruption and with steadily increasing pressure. Introduction of air or steam between filtering and washing, for instance, is impossible. Also a clearance must be left between the cakes of at least ¼ in. to facilitate an easy and even distribution of the washing fluid.

Besides these very great advantages over the ordinary chamber press in respect to time and efficiency of washing, there are a number of others as, for instance, lower operating pressure, absolutely clear filtrate, less leakage and less pressure required for keeping joints tight, which means a saving in blankets.

A plate and frame filter doing such efficient work compares very favorably with a leaf-type filter equipped with the best mechanical devices for discharging the cakes. I am able to prove this with the aid of figures obtained from presses working on the same material and under identical conditions.

| | Washing efficiency | Final moisture content | Lbs. of dry solids per sq. ft. filter area per hour |
|---|---|---|---|
| I, chamber press.......... | 20% | 30% | 0.8 |
| II, improved chamber press | 60% | 28% | 3. |
| III, leaf-type press....... | 54% | 36% | 3.5 |

As to the calculation of the washing efficiency of a filter press as given in the table I shall explain this more fully later on.

A glance at the collated figures reveals clearly the inferior work done by the old chamber press. Its washing efficiency is only one-third of that of the two other presses, and consequently the output for unit filter area which is chiefly influenced by the washing efficiency is still less, about one-quarter. It is evident that this press drops out of consideration for processes in which large amounts of material have to be filtered and where wash-water means evaporation.

A comparison of the presses II and III proves that my previous statement as to the capacity per unit filter area being principally determined by the washing efficiency is correct. The difference in the quantity of cake handled per square foot per hour in this particular case was only 0.5 lb., or 14 per cent. This is small, indeed, and will only have an influence in favor of the leaf-type press when huge quantities of material are to be put through, but then it is rather the saving in labor which will enter into consideration. On the other hand the lower moisture content of the cakes obtained in the improved chamber press is decidedly a great advantage whenever the residue is to be dried. That together with the somewhat higher washing efficiency will outweigh the labor item, which is in favor of the leaf-type filter. Moreover, the simplicity of replacing a leaky blanket is a matter not to be overlooked.

* * * * *

In connection with the description of the new filter press just given I intend to add a few suggestions concerning a standard method of putting down the work done by a filter. I think there can be no question as to the usefulness of such a scheme. Filtering is one of the most important operations in many chemical and metallurgical processes, and the machines are so numerous that figures computed in a like manner as to the work done by them would be most interesting and valuable. It would be of help to the engineer interested in some particular process, as well as to the man who is offering a machine for effecting the separation of a liquid from solid matter.

The data given before and which I used for comparing three different types of presses defined pretty well the performances of each machine. One figure relates to the amount of water needed for washing the cakes—no doubt in many cases the most important item—the second tells the condition of the discharged cakes, and the third data gives the amount of material handled per hour and per square foot filter area when operating continuously.

With regard to the amount of water required for practically complete extraction of soluble matter from the cakes, we often hear it expressed in gallons per ton of dry solids. While this is quite sufficient for one familiar with the material worked to do some figuring, it conveys no direct impression as to how efficient washing is carried out. For this reason I prefer to base the calculation of this item on the displacement principle, calling the washing 100 per cent efficient if the volume of water required for practically complete extraction is equal to the volume of solution the cakes contain after they have been built up.

Figs 4, 5 and 6 illustrate this.

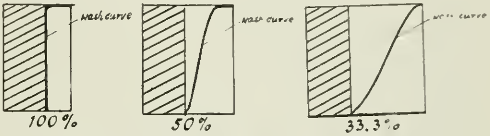
In Fig. 4 (100 per cent washing efficiency) the solution is pushed out of the cake with an equal volume of water.

In Fig. 5 (50 per cent washing efficiency) the solution is pushed out of the cake with twice its volume of water.

In Fig. 6 (33.3 per cent washing efficiency) the solution is pushed out of the cake with three times its volume of water.

A press doing a good work should at least show a washing efficiency of 50 per cent.

The final moisture content gives the amount of water remaining in the cakes when they are discharged. This data will assume importance in all cases where the material has to be dried.



FIGS. 4, 5, 6—100%, 50%, 33.3% EFFICIENCY

The figure as to the amount of solids handled per square foot per hour is interesting as well as important. Interesting inasmuch as it shows—providing the washing efficiency is about equal—to how much those devices for mechanically discharging the cakes amount to; important, because it tells what size filter is required to handle a certain quantity of material in a given time.

68 Bay View Avenue, New Brighton, N. Y.

**Platinum** is worth about $45 an ounce, against $20 five years ago. The United States output of this metal in 1912 was only 721 ounces of crude metal. The world's output for that year was estimated by the Geological Survey to be 314,751 ounces, derived as follows: Russia, 300,000; Canada, 30; New South Wales, 500; Colombia, 12,000; United States, domestic crude, 721; United States, from foreign and domestic matte and bullion, 1300; Borneo, Sumatra and other, 200. The production of the more valuable metals in the United States in 1912, in short tons, is shown in the following table:

| | Quantity | Value |
|---|---|---|
| Platinum | 1.304 | $1,732,221 |
| Gold | 188.108 | 113,415,410 |
| Silver | 4,471.4 | 80,187,317 |
| Aluminium | 32,803. | 15,089,380 |
| Quicksilver | 939.9 | 1,057,180 |
| Nickel | 22,421. | 17,936,800 |
| Tin | 8.4 | 8,850 |
| Copper | 734,052. | 242,337,160 |

**The melting points of some copper alloys** have been investigated by the United States Bureau of Mines, and the results are contained in *Technical Paper* No. 60. The following table contains results of many tests which checked within 5° C.:

| Alloy | Deg. C. | Deg. F. |
|---|---|---|
| Gun metal | 995 | 1825 |
| Leaded gun metal | 980 | 1795 |
| Red brass | 970 | 1780 |
| Low-grade red brass | 980 | 1795 |
| Leaded bronze | 945 | 1735 |
| Bronze with zinc | 980 | 1795 |
| Half yellow, half red | 920 | 1690 |
| Cast yellow brass | 895 | 1645 |
| Naval brass | 855 | 1570 |
| Manganese bronze | 870 | 1600 |

## The Russian Chemical Industry

[*Special Correspondence from St. Petersburg*]

The chemical industry in the Urals has been quite an exceptional business up till recently, partly because of the geographical position of that mining district, and partly because of the economic conditions existing there. If we leave out the industries of the Kam river district the products and by-products prepared at the Urals chemical works generally are consumed entirely by the local concerns, and only a relatively insignificant quantity is sent into the interior market and into Siberia. Only special products, such as bichromate, for which the district holds practically a monopoly in view of the favorable natural conditions, are exported to more distant European and Asiatic Russian markets.

On the other hand, exceptionally favorable conditions would exist for the production of sulphuric acid in the Urals, because of the deposits of pyrites and the fine quality; but is prepared on the spot in very limited quantities, almost exclusively for local requirements, such as the preparation of galvanized iron and the working of copper ores, etc. The relatively small quantity that reaches the markets for various small uses need not be taken into account. As far as is known, in the Urals factories sulphuric acid is hardly used for other purposes, nor are its salts or other derivatives. In truth, at present the general revival of industrial life in the Urals is finding expression in the production of sulphuric acid.

The creation of new galvanized iron factories is causing an extension of existing sulphuric acid factories, and the construction of new ones in the district. Besides this, the organic development of industrial life in the Urals finds its expression in various tendencies in the present chemical industry, showing that it is changing over to a new and more complicated development. The appreciation of the price of fuel, the high cost and insufficiency of labor, are now bringing certain chemical processes to the front which have resulted in the establishment of new chemical factories. As an immediate example we have in view the application of peat for the production of generator gas, and the establishments of dry distillation of wood on modern principles.

The application of peat for the production of generator gas under certain conditions of operation, yields various by-products, amongst these ammonia, which in combination with sulphuric acid, enters the fertilizer industry. One of the largest Urals concerns will shortly begin the extension of its sulphuric acid plant in connection with the production of ammonia from peat.

The question of establishing in the Urals an efficient factory for dry distillation of wood is largely dependent on the question of expensive fuel. The production of charcoal is usually done under very primitive conditions, and a large quantity of valuable products disappears together without profit. The establishment of dry distillation of wood under efficient conditions using the acetic acid and the wood spirit, and perhaps even turpentine, would make it possible to considerably reduce the cost of charcoal for metallurgical purposes.

Considering all these things, the government of the Kyshtim mining district is building a factory for the dry distillation of wood, which in a very short time will be started to work. It is easily understood that the establishment of all these new concerns intimately connected with the conditions of the present day development of the Urals mining industry, must result in the development of associated branches of the chemical industry; both for the purpose of providing the necessary raw materials, and for the further preparation of finished goods. On the other hand, a market must be found for the products; for the Urals chemical industry hitherto has had to work within very narrow limits in this respect.

The most interesting development in respect to technical improvements is the tendency obvious at the moment to utilize the sulphur fumes from the copper roasting furnaces. If these sulphur fumes which are now liberated directly into the open air were taken and resolved into sulphuric acid we should obtain an immense quantity of this product at a very low price. Analogous conditions exist in Silesia, where the recovery of sulphurous gases obtained during roasting zinc blende has resulted in the formation of an immense sulphuric acid and superphosphate industry, which exports from Germany into all directions, to Russia, Austria-Hungary, Servia, Roumania, etc.

If it were possible to establish such an industry in the Urals in connection with the roasting of copper ores, the Russian market would be able to dispose of a colossal quantity of sulphuric acid—two or three times more than the existing demand for it in the country. At first, naturally, it would be difficult to place such a large quantity of acid; but it is thought a large quantity of sulphuric acid could find a relatively easy market in the superphosphate industries of the country in the near future. This is the direction which should be taken by those who are studying the question of waste sulphur fumes. Unfortunately information on the phosphate deposits of the Urals does not tend to encourage the hope of an early extensive establishment of a superphosphate industry there, to yield a cheap manure for our eastern and central districts, where it is so much wanted. In any case the first steps in this direction are now being taken, and judging from the information gathered over the widely extended area, including the Kyshtim mining district, it may be noted that the utilization of sulphur gases recovered from three copper roasting furnaces is already being effected, each of these furnaces burning 2500 poods of pyrites per day.

We are probably entering quite a new era in the development of the chemical industry of the Urals, particularly in reference to artificial manures. And although it is quite true that the analyses of the Urals phosphate deposits is not an encouraging one, they can still be used with a cheap sulphuric acid and produce a superphosphate which will be of greater relative value to the local agriculturist than would be a richer manure after having to pay the enormous cost of transportation from Western or Southern Russia. Thus while Southern Russia becomes an exporter of sulphate of ammonia the Urals is probably entering into a state of independence with respect to artificial fertilizers, which are two very notable developments in the Russian chemical industry.

---

**The Arizona Copper Co.** produced, during December, 1913, 1460 tons of copper.

**The Thomas Mellen Company**, Portland cement manufacturers, Jamesville, N. Y., have broken ground for their new cement stock-house and expect to be able to run cement into the same before February 1, 1914. The building will be of steel and concrete with self-emptying bins. At one end will be located a pack house equipped with Bates-Valve soaking machines. This will be the first of extensive additions to be made to the plant in the next year. Owing to the high quality of the product and the consequent popularity of the brand in Syracuse, Rochester and northern central New York, the company has found the enlargement of their plant necessary. Richard K. Meade, chemical, mechanical and industrial engineer, 203 N. Calvert Street, Baltimore, Md., has been retained as engineer and prepared the plans and specifications for the new stock house.

# Extinguishing of Fires in Volatile Liquids[*]

BY EDW. A. BARRIER

The extinguishing of fires in oils and in most of the volatile liquids has always been a difficult problem, and where fires of this kind occur the results are frequently very disastrous. Our most common extinguishing agent, water, works rather unsatisfactorily upon the majority of such fires, but it is still the only one available where heroic measures are required. Comparatively recently, however, there have been two or three other materials introduced for use as extinguishers which have shown some promise for dealing with these fires.

Not all fires in volatile liquids are difficult to handle with water. When the liquid is miscible with water this extinguishing agent can be successfully used. Examples of this kind are denatured alcohol, wood alcohol, grain alcohol, acetone, etc. Where the liquid is not miscible with water little or no effect is produced except to wash the burning liquid out of the building where it my be completely consumed or, if the quantity of oil is small, possibly to extinguish the fire by the brute cooling effect of a large quantity of water sprayed upon the fire. Soda and acid extinguishers are somewhat more effective than pure water, but even they fail under most conditions. The various grenades containing salt solutions which were formerly extensively exploited are, of course, practically worthless.

The only principles that can be made use of in extinguishing fires in volatile oils are, (a) to form a blanket either of gas or of solid material over the burning liquid which will exclude the oxygen of the air, or, (b) to dilute the burning liquid with a non-inflammable extinguishing agent which is miscible with it.

### Sawdust and Bicarbonate of Soda

To the blanketing type of extinguishers belong sawdust. Paradoxical as it may seem, ordinary sawdust is an excellent extinguishing agent for certain volatile liquids, especially those of a viscous nature. A considerable number of experiments were conducted in the fall of 1912 by the inspection department of the Associated Factory Mutual Fire Insurance Companies, in the extinguishing of fires in lacquer and gasolene in tanks with sawdust, and the results were surprisingly satisfactory.

The liquids were placed in three tanks 30 in. long, 12 in. wide and 16 in. deep; 48 in. long, 14 in. wide and 16 in. deep, and 60 in. long, 30 in. wide and 16 in. deep. The sawdust was applied with a long-handled, light but substantially built snowshovel having a blade of considerable area. In every case the fires were extinguished readily, especially in the ttwo smaller tanks, which were about as large as any ordinarily employed for lacquer in manufacturing establishments.

The efficiency of the sawdust is undoubtedly due to its blanketing action in floating for a time upon the surface of the liquid and excluding the oxygen of the air. Its efficiency is greater on viscous liquids than on thin liquids, since it floats more readily on the former than on the latter. The sawdust itself is not easily ignited and when it does become ignited it burns without flame. The burning embers have not a sufficiently high temperature to reignite the liquid.

The character of the sawdust, whether from softwood or hardwood, appears to be of little or no importance, and the amount of moisture contained in it is apparently not a factor, so that the drying out of sawdust when kept in manufacturing establishments for a time would not affect the efficiency.

It was found that the admixture of sodium bicarbonate greatly increased the efficiency of the sawdust, as shown both by the shortened time and the decreased amount of material necessary to extinguish the fires. A further advantage of the addition of bicarbonate of soda is that it decreases the possible danger resulting from the presence of sawdust in manufacturing plants since it would be difficult, if not impossible, to ignite the mixture by a carelessly thrown match or any other ready source of ignition.

Although the efficiency of the sawdust is greatest on viscous liquids such as lacquers, heavy oils, japan, waxes, etc., in the tests referred to, fires were extinguished in gasolene contained in the smallest tank and also when spread upon the ground. In larger tanks the sawdust or bicarbonate mixture does not work so well since the sawdust sinks before the whole surface can be covered, whereupon the exposed liquid reignites.

### Carbon Tetrachloride

In recent years carbon tatrachloride has received considerable attention as a fire-extinguishing agent. This is due largely to the activity of certain manufacturers of fire extinguishers which use liquids, the basis of which is carbon tetrachloride.

This substance is a water-white liquid and possesses when pure a rather agreeable odor somewhat similar to chloroform. A considerable proportion of the commercial article upon the market, however, contains sulphur impurities which impart a disagreeable odor to the liquid. The substance is quite heavy, its specific gravity being 1.632 at 32 deg. Fahr. It is non-inflammable, non-explosive, and it is readily miscible with oils, waxes, japan, etc. When mixed with inflammable liquids it renders them non-inflammable provided a sufficient quantity is added. Its vapor is heavy, the specific gravity being about five and one-half times that of air, consequently it settles very rapidly.

As an extinguishing agent it operates by both the principles mentioned above, namely, it diluted the inflammable liquid rendering it non-inflammable, or at least less inflammable, and it forms a blanket of gas or vapor over the burning liquid which excludes the oxygen of the air.

It may not be out of place to mention that the claims made by certain manufacturers producing extinguishers which use liquids, the basis of which is carbon tetrachloride, are grossly exaggerated. These preparations, none of which is more efficient than carbon tetrachloride, are not the equivalent of the ordinary water extinguishers for general use on such materials as cotton, wood, paper, oily waste, etc.

On volatile liquids, oils, etc., carbon tetrachloride has, however, shown very satisfactory results under some conditions, but the readiness with which a fire can be extinguished with it depends to a considerable extent upon the skill of the operator and the nature of the fire. In tank fires the length of time that the liquid has been burning is an important factor, and in such cases where the sides of the tank become heated the only way in which the fire can be extinguished is to squirt the liquid forcibly at the sides. If the carbon tetrachloride is squirted directly into the liquid it is much more difficult, if not impossible, to extinguish the fire.

The height of the liquid in the tank is also a very important factor. Where the liquid is low the sides form a pocket which retains the vapor and aids considerably in smothering the blaze. When the tank is nearly full, however, this condition does not exist, and it is then very difficult, if not impossible, to extinguish a fire in a highly volatile liquid, such a gasolene; only the most skilled operators are successful in these cases. The size of the tank or the extent of the fire if upon the floor is, as would be expected, of considerable importance. In tanks larger than about 28 in. by 12 in. more than one extinguisher and operator working at a time are necessary to extinguish a fire in such materials as gasolene. In one test where a tank 60 in. by 30 in. was used no less than seven operators were necessary, and even then it was only with the greatest difficulty that the fire was put out.

---

[*] Slightly abstracted from the December, 1913, issue of the Journal of the American Society of Mechanical Engineers. The author is a member of the Inspection Department of the Associated Factory Mutual Fire Insurance Companies, Boston, Mass.

All of the above remarks apply to carbon tetrachloride in the ordinary one-quart extinguisher as generally sold. It is probable that a large extinguisher which could throw a large stream would prove more efficient, but on account of the great weight of carbon tetrachloride such an extinguisher would have to be specially designed to make it readily portable by mounting on a truck or some similar means. Expelling the liquid by means of a hand-pumping arrangement would probably be unsatisfactory, and it would, therefore, be necessary to force it out in some other way.

A few systems have recently been installed in which an elevated tank containing carbon tetrachloride was connected with automatic sprinklers or perforated pipes located in hazardous rooms where volatile and inflammable liquids are in use. So far as is known none of these systems have as yet been called upon to extinguish a fire, but there appears to be no reason why such a system should not provide excellent protection in special cases. In such systems it would be necessary to consider the safety of the workmen and furnish ready means of escape, since carbon tetrachloride is an anesthetic and where thoroughly sprayed through the air, as from an automatic sprinkler, it would probably produce rapid results.

The nature and effect of the fumes given off when carbon tetrachloride is thrown upon a fire is a subject which has received a great deal of discussion. When the liquid comes in contact with a fire the vapor is partly decomposed, resulting in the evolution of a considerable quantity of black smoke which is undoubtedly finely divided carbon. Pungent gases are also produced which appear to be mostly hydrochloric acid, with possibly a small amount of chlorine. Since carbon tetrachloride contains no hydrogen from which hydrochloric acid could be formed, this substance must be produced by the action of chlorine on the gases arising from the burning material or upon the moisture of the air.

The fumes of carbon tetrachloride, although of a very pungent nature, do not produce any permanent injury under ordinary conditions where the operator can make his escape after he has inhaled all he can stand, but they are distinct handicaps in fighting a fire and are one of the objectionable features to carbon tetrachloride as a general fire extinguishing agent. In large rooms or where a small quantity of carbon tetrachloride is sufficient to extinguish a fire, the gases are, of course, less objectionable.

### Frothy Mixtures

Another method of extinguishing fires in oils and volatile liquids which has recently been proposed and experimented with is that of using frothy mixtures. The idea seems like a very promising one and the tests which have been thus far reported indicate very satisfactory results. The idea was originated and has been developed in Germany. So far as is known no experiments have been conducted in this country.

The process consists essentially in causing two liquids to mix in a tank where foam is produced. The tank is made airtight and sufficiently strong to permit of the foam being forced out by carbon dioxide under pressure, and the foam is conveyed to the fire by means of a line of hose. The exact nature of the liquids has not been disclosed, but one of them probably consists of a sodium-carbonate solution containing froth-forming ingredients such as glue or casein and the other an alum solution. The two on coming together generate carbon dioxide which produces froth. This froth is reported to be quite stiff and to shrink in volume but a comparatively small amount even after a period of half an hour.

A number of tests were conducted in the winter of 1912 in Germany; some of them on a considerable scale. In one case as much as 5 tons of crude naptha in a tank was involved, and in another an area of 1300 sq. ft. of burning tar was used. In all cases the results were reported satisfactory, the fires being extinguished in a short time.

The frothy mixture undoubtedly owes its efficiency to its blanketing action in settling upon the surface of the burning liquid, thus excluding the oxygen of the air, and to the fact that the bubbles of liquid contain carbon dioxide which upon bursting produce an atmosphere in which combustion cannot take place.

According to the latest reports the matter is still in an experimental stage, various details regarding the form of apparatus, most efficient pressure and design of nozzles being under consideration; but from what has already been done it would appear that the idea is a very promising one, and that this method of extinguishing fires in oils and volatile liquids will prove to be by far the most efficient of any that has as yet been suggested.

## Efficiency Exposition

The first national Efficiency Exposition and Conference will be held in the Grand Central Palace, April 4 to 11, inclusive, 1914. Its aim and purpose will be to give living expression to the increasing application of scientific methods to modern conditions.

The plan and scope of the show will include displays of efficiency appliances, methods and products in industrial, mechanical, governmental, educational and household fields. Not the least interesting feature of the show will be a series of mental and manual efficiency contests which will be staged along original lines and conferences and illustrated lectures on subjects of vital current interest.

The exposition will be held under the auspices of the Efficiency Society and in conjunction with the conferences of the Society and other scientific organizations.

Mr. William R. Wilcox, ex-chairman of the Public Service Commission, will, as president of the Efficiency Society, preside over the exposition which includes on its Advisory Committee such well-known names as F. H. Bethel, vice-president New York Telephone Company; James G. Cannon, president Fourth National Bank; Norman Hapgood, editor Harper's Weekly; William A. Marble, president Merchants' Association of New York; William A. Prendergast, comptroller City of New York; Lawson Purdy, president Department of Taxes and Assessments; Elbridge G. Snow, president Home Insurance Company; Arthur Williams, general inspector New York Edison Company; T. S. Williams, president Brooklyn Rapid Transit Company; Joseph French Johnson, dean New York University. Travis H. Whitney is the chairman of the Executive Committee.

**Leadville's metal production** for 1913 was valued at only $9,040,350, being about $2,000,000 less than for 1912. The total tonnage of ore mined was 453,360, of which 1/3 was zinc carbonate. The grand total value of Leadville's production to date is calculated locally as $406,451,061.

## Nitrates by Electrolysis of Peat

In an article in London *Electrical Review*, of December 19, 1913, Mr. Georges Dary describes a new scheme for utilizing peat deposits. The object is to produce from them nitrates by electrolysis. The inventor is Albert Nodon, the French electrical engineer, who has formerly become known by his work on the electrolytic aluminum valve. We quote the description of the process verbatim from the article of Mr. Dary.

"**M. Albert Nodon** has continued the research work of Mr. Müntz, and, as a result of long and exhaustive tests, has recently discovered an extremely economical process of extracting nitric acid and nitrates by treating peat deposits electrolytically. The process has recently been patented in the United Kingdom, to which country it is especially suited. By its means calcium nitrate, which is formed in considerable quantities and continuously in peat deposits can, in fact, be decomposed by electrolysis, the nitric acid passing to the anode, which is enclosed, while the lime accumulates about the cathode.

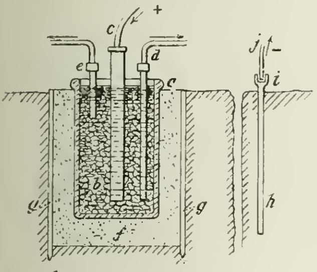


FIG. 1—ANODE AND CATHODE ELEMENTS

"The operation is effected automatically and continuously by means of a simple and cheap plant installed in the open air directly on the peat deposits, this accounting for the fact that the cost of production is practically restricted to that of the current consumed. The Nodon process, in fact, renders the usual heavy expenditure for the extraction, transport, and lixiviation of the peat entirely unnecessary, thus overcoming all the drawbacks which lead to the rejection of the Müntz scheme.

"The industrial arrangement of the Nodon method may be outlined as follows: Porous pots, filled with coke, which is utilized as the anode, and a weak solution of nitric acid, are installed at equal distances directly in the peat deposits. The nitric acid obtained by the electrolysis of the nitrates of the earth is gathered into tanks, while the lime resulting from the decomposition into calcium nitrate is collected by the cathodes, which latter consist of iron rods sunk into the deposits. Each anode element (Fig. 1) consists of a cylindrical porous pot *a*, of coarse pottery, rendered porous by the addition, before baking, of a paste of combustible dust. The pots which are 8 ft. 2 in. in height x 15¾ in. in diameter are sunk into holes dug in the peat, care being taken to tightly ram the earth below in order that there shall be no movement in the pots. Each of the latter is filled with washed coke, a large rod of graphite *c* being placed in the center of the same, its center being to convey to, and distribute, the positive current through the coke.

"It is very necessary that a perfect joint should be made between the graphite rod and the electric cable, as in batteries; with the view of ensuring this, the upper end of the rod is coppered, lead being cast between this and the end of the coppered conductor. Two glass tubes *d* and *e* project into the porous pot. The tube *d* extends practically to the bottom, while the other only penetrates just below the surface of the liquid. The object of the first tube is to draw off the water impregnated with nitric acid; while the tube *e* serves to replenish the pot with an amount of water equal to the liquid drawn off. Round each pot a circular space *f* is left, which is filled with calcium carbonate, or simply broken limestone. Stakes of tarred wood *g* separate the peat from the annular space, which forms a sort of cage for the limestone.

"The cathodes or negative poles *h* are of rough cast iron, and are of a square bar section, 8 ft. 2 in. in length. The upper end *i* is made of a cup shape, into which antimoniated lead is poured, in order to make a good connection with the conductor *j*. The whole is carefully tarred with the view of obviating any destructive action. The rods are located at a distance of approximately 4 in. from each other, and are connected to a common conductor *k* (Fig. 2). In this way a cathode of a large surface is secured.

"The porous pots are fixed at a distance of 3 ft. 3 in. from each other, the shortest space between any of the anodes and cathodes being 1 ft. 7½ in.

"As soon as the current is switched on, the following phenomena are observed: The ground of the peat bog may be regarded as an electrolyte, the specific resistance of which has been found equal to an average of 3 ohms per meter cube. This resistivity necessitates the employment of a pressure of 10 volts in order to secure sufficient current density. Under the action of this current nitric acid is produced at the anode, and lime at the cathode. . . .

"The nitric acid remains dissolved in the porous pots *a*; the solution is drawn off along the tubes *d*, and conveyed to a large storage tank by means of pumps *n*, water being admitted by tubes *e* to make up for the liquid extracted. The solution may be directly concentrated in sandstone evaporators, in order to produce pure nitric acid, for which there is a large demand. . . . The free acid is usually saturated with calcium carbonate. The solution is evaporated in boilers fired with dried peat, a calcium nitrate, similar to that supplied for agricultural purposes, being obtained by crystallization.

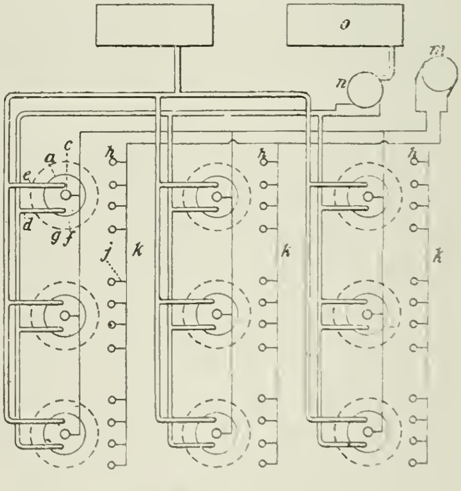


FIG. 2—ARRANGEMENT OF ELECTROLYTIC CELLS

"Peat is particularly adapted for the intensive production of pure nitrate; in fact, 2 per cent of its weight consists of nitrogen capable of being converted into fixed nitrogen under the simultaneous action of the nitric ferments, the oxygen of the air contained in the porous mass of peat, the hygrometric water and the heat developed by the passage of the electrical current.

"The flow of the current in the peat does not sensibly reduce the activity of the nitric ferments, so long as the density per unit of surface of electrodes is not too high.

"It is thought advisable to mix calcium carbonate with the peat, or, simply, a lime milk resulting from the lixiviation of the lime, which accumulates round the cathodes. Without this precaution the peat becomes impoverished as regards calcium, and the nitric ferments will quickly commence to act on the ground rendered acid by the free nitric acid. It is also well to prevent the development in the nitrate bed of ferments capable of paralyzing, as it were, the action of the nitric ferment; this can be done by distributing, by means of a pump, separately-prepared ferment solutions.

"All these operations can be effected quite economically by means of electrically operated pumps and distributing pipes fixed on the peat deposit.

"It has been found that the nitric ferment attains its maximum degree of activity at 25° C., while a continuously flowing current at a pressure of 10 volts is amply sufficient.

"A deposit of peat, having a depth of 6½ ft., and an average richness in nitrogen of 2 per cent, can produce between 800 and 900 tons of pure nitrates per year; while, according to the research work of M. Müntz, if the deposit is located near a town, and can be watered with liquid manure, it can be made to yield 6,000 tons of fixed nitrogen."

* * * * * * * * *

In the article an equation of the reaction is given which is clearly wrong. If the rection as claimed is really the electrolytic decomposition of calcium nitrate, the equation would be

$$Ca(NO_3)_2 + H_2O = 2HNO_3 + CaO$$

corresponding to a passage of 2 x 96,540 coulombs, if the symbols in the equation represent gram-molecules. Theoretically, 2 x 96,540 coulombs would, therefore, produce 126 grams $HNO_3$ or one amperehour 2.4 grams of $HNO_3$.

According to the article 1 amperehour gives 1 gram $HNO_3$ so that the current efficiency is 42 per cent.

Since according to the article the voltage per cell is 10 volts, 1 kw-hour produces 240 grams of $HNO_3$.

In Mr. Dary's article it is stated that for the most efficient operation 2500 porous pots and 36,000 iron rods are required per hectar (1 hectar = 2.47 acres) with a current density of 3.33 amperes per square meter of anode surface, or a current of 7.5 amperes per porous pot. Hence the current per hectar is 18,000 amperes. The production per 24 hours would, therefore, be 18,000 x 24 grams or 950 lbs. $HNO_3$ per hectar with a power consumption of 180 kw and an energy consumption of 4320 kw-hours.

In order to use energy supply at 100 volts, the peat deposit is divided into ten parallel trenches, electrically connected in series in such a way as to give a difference of potential at the two extremities of 100 volts, while using only 10 volts in each of the separate trenches.

Mr. Dary's article contains also a cost estimate, prepared by Mr. Nodon, for a plant for the electrolytic extraction of 100,000 tons of nitrates per year, but as it is only an estimate and based on European conditions, it is not reproduced here. The important figures claimed for the process are that the production of 1 kilogram of HNO requires 1000 ampere-hours and 10 kw-hours.

---

The National Association of Manufacturers of Medicinal Products will hold its annual convention on February 10th in New York City.

## Ductile Tungsten Patent

What must be considered as the fundamental patent for making ductile tungsten has now been issued. It is patent No. 1,082,933, granted on Dec. 30, 1913, to Dr. William D. Coolidge, of Schenectady, N. Y., and assigned to the General Electric Company. It relates to "Tungsten and Method of Making the Same for Use as Filaments of Incandescent Electric Lamps and for Other Purposes." The serial application in this case, filed June 19, 1912, was in part an extension of four prior applications, the earliest under date of July 2, 1906. The invention covered by this patent is the now well-known ductile tungsten for incandescent-lamp filaments and other uses, which was discovered in the research laboratory of the General Electric Company.

One of the interesting features of this patent is its history in the Patent Office. The primary examiner rejected the entire application on the ground of prior disclosures in British patents No. 21,513 of 1906, No. 3174 of 1907, No. 16,530 of 1907 and No. 24,179 of 1906. The examiner also held that certain claims should be divided, under another application, and that some of the other claims were duplicates in patentable effect. In a decision of the board of examiners-in-chief, filed on Nov. 15, 1913, the citation of the first three British patents named above was rejected on account of their having been filed subsequent to July 2, 1906, the earliest filing date in the Coolidge application. The members of the board also dismissed the other contentions of the primary examiner except as to duplication of claims, and the latter ruling was over-ruled by the examiner-in-chief, so that the original application was finally allowed intact.

Out of the thirty-four claims in the patent we quote the following:

"1. The process of producing tungsten having a fibrous structure which consists in repeatedly hot-working a crystalline body of tungsten until the crystalline structure is broken down and a fibrous structure developed.

"2. The process which consists in agglomerating tungsten powder, sintering the body thus formed, subjecting it to repeated hot-working, and continuing such hot-working until the body remains ductile when cold.

"8. The method of producing pliable tungsten wire for lamp filaments, which consists in first producing a body of tungsten in a sintered state and free from oxygen carbon and other impurities which would render the body unworkable mechanically and then subjecting this sintered and purified body to mechanical working many times repeated, with gradual reduction in diameter and elongation in length.

"12. The process which consists in reducing tungsten oxide to coarse tungsten powder, agglomerating said powder into a coherent porous body, heating said body to drive out impurities and sinter the body, and then subjecting the body to hot mechanical working.

"14. The process which consists in forming a body of tungsten powder containing additional material which will prevent coarse crystallization of the tungsten at high temperature, sintering the body and then subjecting it to hot mechanical working.

"22. The method of securing a ductile metal body without previous melting of the metal, which consists in producing a compact body of metal from divided metalliferous material, consolidating said body by heating to a temperature less than the melting temperature and such as to produce a body of metal non-ductile when cold, subjecting the body to repeated mechanical working while in a heated condition, and continuing the working until the body is ductile without the application of heat.

# The Kieselguhr Industry

BY PERCY A. BOECK

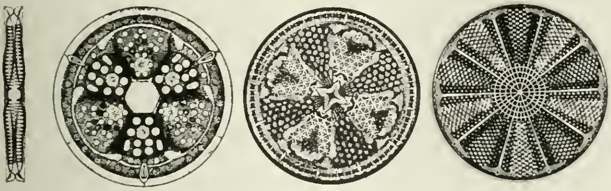
Many of the uses of kieselguhr, also known as diatomaceous earth, Tripoli, Sil-O-Cel, and sometimes as infusorial earth, have long been known. The ancient Greeks and Romans made the so-called "swimming brick" and the emperor Justinian, in 522 A.D., ordered the dome of the Hagia Sophia built of brick made of this material to lighten the weight of the structure.[1]

Since that time the applications of this material have increased in an almost endless variety of uses. It has not been until recently, however, that the use of kieselguhr in the industries has been developed systematically. This has been brought about to a great extent by the present-day keen competition, which has compelled closer attention to by-products and wastes, and by the ever-increasing tendency toward efficiency in industrial plants through the reduction of losses from all sources to the lowest possible point.

The available technical literature dealing with kieselguhr is not only limited in amount, but it is widely scattered and generally inaccessible. It is not the purpose of this article to attempt to enumerate or catalog all of its various uses, but rather to summarize and discuss briefly its nature and properties in such a way as to bring out the principal applications of this important, and, in this country, somewhat neglected mineral.

## Formation

Kieselguhr deposits are formed by the precipitation of the remains of bacillariæ or diatoms, one of the groups of flowerless aquatic plants of the species "algæ," which occur almost universally in all waters from arctic to torrid, fresh or salt, still or running. There are innumerable varieties of diatoms, over 4000 distinct forms having been classified and described. These vary greatly in size from that of a head of a pin easily visible to the naked eye, down to such a minute size as to be revealed only by the highest power of the microscope.



FIGS. 1 TO 4.—DIATOMS LARGELY MAGNIFIED

The silica shell or casing of these plants is secreted by the assimilation of inorganic substances in solution in the water about them through the agency of sunlight in conjunction with the chlorophyl masses which compose the bodies of the plants. Diatoms multiply with great rapidity and float about in the water or on its surface while living. When the organism dies it sinks to the bottom where the countless myriads of shells accumulate, carrying down with them varying amounts of undecomposed organic matter of which a part remains even centuries after.

The valves or shells of which there are always two exact counterparts are in many instances elaborately carved and ornamented with the most intricate and delicate designs of marvellous variety, which make these plants the most ornate of all living organisms, and has properly earned for them the title of "Jewels of the Plant World."[2] A magnification of from 200 to 500 diameters is usually sufficient to reveal the finer and more delicate tracings on these shells, but occasionally much higher magnifications are necessary. The microphotographs shown in Figs. 1 to 4 give some idea of the variety and nature of diatoms in American samples of kieselguhr.

## Composition of Kieselguhr

The accumulations of these diatomaceous shells is in most deposits contaminated by interposed impurities which also settle to the bottom of bodies of water or are carried along with the sinking diatoms. This may be in the form of diatomaceous ooze, silt, clay, sand or volcanic ash and other inorganic materials from which it is commercially impossible to separate the diatoms. In a few deposits such as that which is found near Lompoc, California, the diatoms occur in enormous beds of unusually pure and uncontaminated kieselguhr. Analysis of several materials from this deposit show the following composition on the moisture free basis:

Sample (1) Very light-weight pure white kieselguhr.
(2) Light-weight brownish kieselguhr
(3) Compact diatomaceous shale.

| | (1) | (2) | (3) |
|---|---|---|---|
| Silica ($SiO_2$) | 88.78% | 85.28% | 94.59% |
| Alumina ($Al_2O_3$) | 2.68 | 5.35 | 1.87 |
| Iron oxide ($FeO$) | trace | 1.12 | .76 |
| Titanium oxide ($TiO_2$) | 0.10 | 0.21 | 0.10 |
| Lime ($CaO$) | 1.61 | 1.12 | .83 |
| Magnesia ($MgO$) | 1.30 | 1.30 | trace |
| Loss on ignition | 5.54 | 5.57 | 2.22 |
| Color | White | Ivory | White |
| Color after ignition | White | Pink | White |

In its natural state kieselguhr contains from 25 to 45 per cent of moisture which is expelled at 100 deg. C., and is pure white to brownish, very light weight, soft, easily abraded material. The condition of the silica, its principal constituent, is one of the characteristic properties, it being in the amorphous or opaline state carrying ordinarily from 5 to 10 per cent of combined water. In many cases this silica has been erroneously reported by some of the older writers as "colloidal silica," this term being used synonymously with amorphous silica, due in all probability to the vague understanding of the term. This, however, must not be taken to indicate that kieselguhr has no colloidal properties, for as a matter of fact these properties are strongly marked but variable, similarly as in a great many clays and show a decided absorption with malachite green oxalate. In certain cases a higher absorption of this dye is obtained by kieselguhr than on samples of Fuller's Earth, in which the bleaching or clarifying action has been shown to be due to a large extent to the physical condition of absorption and dependent on the colloidal content of the earth.[3] The condition of the silica in kieselguhr is further indicated by the fact that it is easily decomposed by means of hydrofluoric acid, is soluble in solutions of sodium carbonate of all strengths and yields water on heating in a closed tube. The specific gravity of kieselguhr is approximately 2.1 to 2.2 at 25 deg. C.; indicating that it is amorphous silica, which is usually taken as 1.9 to 2.3.

## Lompoc Deposit

The geology of this deposit has been studied extensively by Mr. W. B. Schilling, E. M., who gives the following description: The deposits of kieselguhr of Northern Santa Barbara county, California, are largest and best of any known deposits and of great importance because of their pure state and workable condition. In the region immediately south of Lompoc there occurs a deposit of literally mountains of this material owned privately in one tract almost chemically pure and covering an area of many square miles. Fig. 5 shows a mountain of kieselguhr at Lompoc, California.

---

[1] *D. Toepf. und Ziegl. Ztg.*, 1876, pp. 92, 148

[2] Mann: Smithsonian Miscell. Coll., v. 48.

[3] C. L. Parsons: Mineral Technology, Bureau of Mines, Bul. 71

This deposit occurs in the Monterey or Middle Miocene formation. All gradations from the soft diatomaceous material to the hardest of black flints may be found, thus indicating the extreme localization of the conditions that produced the harder varieties from the unaltered deposits. In some places the material is in great soft masses in which the bedding cannot be recognized except by the characteristics weathering into flakey layers parallel with the original bedding planes. Everywhere else it is more compact and in thin beds, ranging from one-half an inch to two and three inches in thickness, or in massive beds. The beds are tilted and in conformity with the much disturbed hard bed of flinty shale of the lower portion of the Monterey formation, of which the whole series is a part. The least known thickness of this deposit in a pure state is 700 feet.

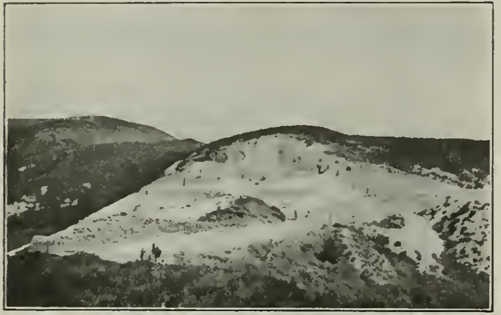


FIG. 5—A MOUNTAIN OF KIESELGUHR AT LOMPOC, CAL.

## Mining and Milling

The mining or quarrying of this material is carried on by means of an open face workings where the kieselguhr is taken up in huge blocks. (See Figs. 6 and 7.) This operation is made easier where transverse seams occur in the strata, due to local folding. Where these seams do not occur it becomes necessary to loosen the kieselguhr slightly by means of powder before the blocks can be removed from the quarry face.

Owing to the peculiar physical structure of the kieselguhr it has for ages been absorbing the surface waters and it is necessary that the material be split into convenient blocks for piling and drying, as shown in Fig. 8. The amount of absorbed water is about 25 to 45 per cent by weight and owing to the winds and dryness of the atmosphere of Southern California, this amount is reduced to about 5 per cent by natural air drying within forty to fifty days.

After drying the kieselguhr is hauled by means of motor truck to the reduction works where it is reduced and transferred by means of a pneumatic system to the different warehouses. It is likewise drawn to the finishing mill from the warehouse by this means and ground and blown into the several grades used commercially. When blocks are required the material is transported in its natural state direct from the quarry, sawed into the sizes required for building purposes and dried before shipment. Waste material too fine to be dried is utilized in the making of brick, tile and other refractory materials of light weight.

## Properties of Kieselguhr

The general characteristics which make kieselguhr of great commercial importance for various purposes may be outlined as follows:

- I. *Physical.*
  - (a) Form.
    - (1) Enclosed air cells.
    - (2) Large exposed surface of cells.
    - (3) Fine state of division.
    - (4) Sharpness of cells.
    - (5) Weakness or low compressive strength of cells.
  - (b) Refractory nature.
  - (c) Presence of large amount of colloidal material.
  - (d) White color.
- II. *Chemical.*
  - (e) Siliceous or inorganic nature.
  - (f) Easy solubility in alkalies.
  - (g) Insolubility in acid or neutral solutions.

The detailed description of these properties will be taken up in connection with the most important of the applications which depend on the specific property under consideration.

## I. Physical Properties

### 1. ENCLOSED AIR CELLS

The highly porous condition of the diatoms is shown in the microphotographs of Figs. 1 to 4; they, however, do not indicate the extent of this most important property as well as the statement of the amount of solid material in a unit volume.

*Light Weight.*—The apparent specific gravity of the raw blocks, as they are mined, after drying, varies considerably, depending upon the amount of material transformation which has taken place at the particular deposit. The apparent density of the dry, crude blocks is about 0.45 equivalent to 28 pounds per cubic foot, while that of the pulverized material, made from them, when loosely packed, has an apparent density as low as 0.13, equivalent to 8 pounds per cubic foot, which can be doubled with packing. In other words, in one cubic foot of the loose material there is but 0.058 of a cubic foot or 100.2 cubic inches of silica having a density of 2.2.

FIG. 6.—AN OPEN KIESELGUHR QUARRY FACE

*Filler or Diluent.*—This unusual bulkiness and light weight makes this material an excellent filler or addition agent for increasing the volume of materials largely without appreciably increasing their weight, and has found extensive application in the manufacture of light-weight tile, brick, partition-tile and as a filler for almost any character of bonding material. As an addition to portland cement it has been found that the strength is increased particularly on aging and completely preventing the destructive action of sea water

(Feret test for durability) for more than two years.[4]

*Thermal Insulator.*—The microscopic voids or "dead air" cells in and between the diatoms form an excellent natural barrier to the passage of heat making it the most effective inorganic thermal insulator known. This application is one of the oldest and most important of the uses of this material. The thermal conductivity of the dry natural kieselguhr block, loosely packed kieselguhr, and of the kieselguhr insulating brick and firebrick have been found to be as given in table 1, the values for the conductivity *k* being given in gram-calorie seconds, i. e., the transfer of heat between opposite faces of a centimeter cube at a rate of one gram-calorie per second per each degree of centigrade difference in temperature of the faces at the temperatures indicated.

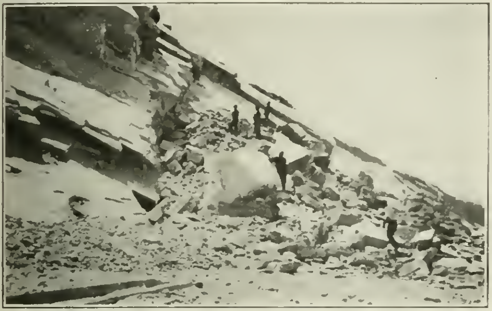


FIG. 7.—QUARRYING KIESELGUHR IN CALIFORNIA

This most important property of kieselguhr has been used extensively for the production of fireproof and incombustible insulator in the form of loose powder, solid natural blocks, burned insulating brick and tile, pipe covering, etc., for both high temperatures in ovens, cookers, furnaces, annealing pits, boilers, evaporators, stills and for low temperatures in cold storage and refrigeration plants, icehouses, iceboxes, coolers and similar purposes. It has the advantages over the organic insulating materials, some of which have a somewhat higher thermal resistivity in that it is unaffected by extreme heat or cold, and is not subject to decomposition, decay or any physical change with time.

*Sound Deadener.*—On account of the same physical properties this material has found extensive use as a "deadener" or sound proofing material in and between the walls and floors of apartment houses, office buildings, school houses, booths, hospitals, etc.

*Absorbent.*—The high porosity of kieselguhr has further brought about its use as an absorbing medium for a variety of materials wherever it is desirable to give the properties of a solid to a liquid or semi-solid material; or in the recovery of waste liquors or by-products not readily available or handled with facility in a liquid form. As an absorbent the uses of kieselguhr are too numerous and varied to mention. Chief among them are fertilizing materials and corrosive liquids. Pulverized kieselguhr absorbs from 150 to 200 per cent. of its weight of water without changing its form. It has also been used for an absorbent or vehicle for liquid disinfectants which are evolved slowly rendering them active for a long period of time.

*Filter.*—For the filtration of liquids the porosity of kieselguhr plays an important part, not only in mechanically retaining the finest suspended matter in the solution, but also aiding materially in keeping the filtering medium and deposited material in an open, porous state, preventing sliming and clogging, producing open, easily handled filter cakes of considerably increased filtering capacity. In the sugar industry both in Europe and in this country, kieselguhr finds almost universal application.

For the filtration of oils, excellent results have been obtained in certain cases by substituting kieselguhr for Fuller's Earth wholly or in part. This is due, in all probability, to a large extent to the high percentage of colloidal material in kieselguhr, as well as to its open and porous structure. Filters of bonded burned kieselguhr have been in use for many years, both abroad, where they originated, and in this country.

In a report on these filters Dr. Martin Kuchner states that filters of this material are four times more efficient than any similar filter as to quality and quantity of filtrate. In a test, bacteria appeared in the filtrate after three days in an ordinary filter, while in the case of kieselguhr no bacteria were found in the filtrate, even after six days of continuous operation without cleaning.[5] These filters are now used exclusively in the preparation of serum, toxines and products of a similar nature. They have lately also come into extended use in the removal of moulds and ferments from beers and fermented liquors.

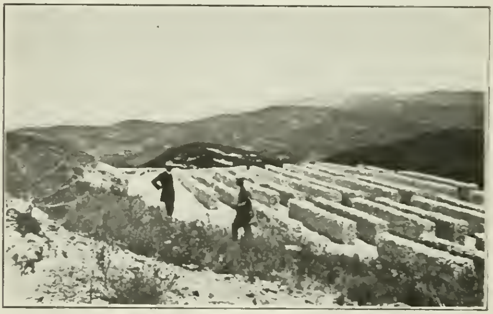


FIG. 8.—KIESELGUHR CORDED OUT TO DRY

### 2. LARGE EXPOSED SURFACE OF CELLS

The large surface presented by the kieselguhr diatoms has brought about its use as a carrier for the active material in several catalizing processes, notably in the hydrogenation of unsaturated oils, in which process, for example, cottonseed or other vegetable oils are converted into the consistency of lard by the addition of less than 1 per cent. of hydrogen to the oil, which reaction is brought about by means of a catalizer, such as nickel oxide deposited on kieselguhr as a carrier. In

TABLE 1—THERMAL CONDUCTIVITY OF KIESELGUHR PRODUCTS in Gram-Calorie Seconds at Various Temperatures

| | Apparent density | 200° C. | 300 | 400 | 500 | 600 | 700 | 800 |
|---|---|---|---|---|---|---|---|---|
| Natural kieselguhr block (dried) | 0.53 | 0.000227 | 0.000259 | 0.000276 | 0.000287 | 0.000298 | 0.000308 | 0.000315 |
| Pulverized kieselguhr (loosely packed) | 0.12 | 0.000127 | 0.000187 | 0.000248 | 0.000294 | 0.000332 | 0.000364 | 0.000397 |
| Kieselguhr insulating brick (burned) | 0.75 | ....... | 0.000448 | 0.000480 | 0.000510 | 0.000542 | 0.000573 | 0.000604 |
| Kieselguhr firebrick (burned) | 1.05 | 0.000371 | 0.000472 | 0.000553 | 0.000623 | 0.000683 | 0.000738 | 0.000791 |

---

[4] Poulson: Trans. Internat. Assn. Test Materials, 1912, et seq.

[5] Zeit. fur Hygiene, 14,299 (1893)

this case the large area of the carrier adds considerably to the activity of the catalizer and also aids in the filtration and removal of suspended matter from the oil after the reaction is completed.[6]

### 3. FINE STATE OF DIVISION

The natural fineness and uniformity of the particles which go to make up kieselguhr and the ease with which it can be reduced without destroying the cell structure make it useful for many purposes, among which are: Polishing and dusting powders and in many industrial and pharmaceutical lines.

### 4 AND 5. SHARPNESS AND WEAKNESS OF CELLS

The angular nature of the flinty skeletons of the diatoms give kieselguhr an abrasive power which is taken advantage of in the finer grades of polishing and cleaning materials, where a mild abrasive is required. The fineness, together with the angularity, weakness and low compressive strength of the diatoms produce a material which is unsurpassed for polishing and burnishing objects without danger of scratching the surface of the softest metal.

It has been used extensively for metal polish, soaps and for polishing metallic specimens for microscopic examination, dental powders, etc. The above properties are also taken advantage of in producing friction surfaces in the manufacture of safety match surfaces, match heads and similar lines.

### b. REFRACTORY NATURE

As the diatom consist chiefly of silica, a material which is in itself of a refractory nature,[7] this valuable characteristic as a whole is imparted to kieselguhr. The melting point of natural powdered kieselguhr has been reported by the Bureau of Standards to be 1610 deg. C. (2930 deg. F.), and that of a lightweight diatomaceous shale 1,750 deg. C. (3,182 deg. F.), indicating its highly refractory nature. This feature, together with its low thermal conductivity, opens up a wide field for its use in the ceramic industries for the production of lightweight brick and tile for insulating and refractory purposes. Owing to the low apparent density of the pulverized kieselguhr it has found extensive application for fire protection in buildings as a light fireproof wall filler. On account of its smothering effect caused by the exclusion of oxygen from the vicinity of the flame, it is also used as a fireproofing and insulating material in safes, ovens, fireless cookers, electric fuse protectors, etc.

### c. COLLOIDAL CONDITION

The bleaching and decolorizing properties of certain clays, notably in the case of Fuller's Earth, has long been known to be due to the presence of colloidal matter.[8] Recent work on kieselguhr has shown that it carries a large amount of colloidal material, as is indicated by its absorption of certain basic dyes. In certain cases this absorption has been found to be as much as 20 per cent. higher than in the case of a high-grade Fuller's Earth, making it of particular value in the treatment and filtration of a number of materials which were formerly carried out only with great difficulty.

### d. WHITE COLOR

The white color of kieselguhr naturally depends upon the small amount of impurities in the material and upon the freedom from deleterious sediments which settle along with the diatoms in many deposits. When of a high degree of purity the pure white color imparts valuable properties to kieselguhr in pharmaceutical applications being used in the preparation of many drugs and dentifrices in which the essential qualities are purity.

## II. Chemical Properties

### e. INORGANIC OR SILICEOUS COMPOSITION

As has been shown above, the chief constituent of diatomaceous remains is silica, which, under certain conditions, is found in a high degree of purity in a form which is readily available, thus forming an ideal source of pure silica for a variety of purposes. It has been used as an ingredient in the compounding of glazes, fluxes and bodies of a siliceous nature. The specific heat of kieselguhr has been determined by Becker to be 0.2089.[9]

### f. SOLUBILITY IN ALKALIES

One characteristic of the silica contained in kieselguhr is the ease with which it reacts and combines with alkalies and alkaline salts, making it a convenient form of silica for the manufacture of silicate of soda or water glass, ultramarine and other siliceous products.

### g. INSOLUBILITY IN ACID OR NEUTRAL SOLUTION

Kieselguhr is not affected by the action of acids (except hydrofluoric) or netural solutions, which feature makes it suitable for the filtration, absorption or transportation of these bodies without contaminating them.

## Testing Kieselguhr

In industrial work it is essential in order to obtain the best results that the kieselguhr which is best adapted to the particular requirements be used. In order that this may properly be determined, it is advisable to apply certain chemical, physical and mechanical tests, which will be outlined. While it is unnecessary in a great many cases to carry out all of these tests in detail, it will be found that they give the general character and adaptability of the material for the purposes intended. For instance, for filtration of materials, the apparent density, fineness and behavior of the kieselguhr in solution will enable a far better valuation of the material to be made than chemical analysis. For ceramic purposes the analysis showing the amount and nature of the fluxes present would be of the greatest importance. In short, the testing of this material should be carried out with an idea of determining the physical properties which have the greatest bearing on the manner in which the material is to be used.

*Sampling.*—On account of the relatively small percentage of material other than amorphous silica present in kieselguhr, and the large surface and porous nature of the material, it is essential that the sampling be done with great care in order that a representative sample may be obtained. For accurate work it is advisable that all samples be weighed out at the same time and the percentage of moisture determined in one of them, and also that the weighing be carried out as rapidly as possible on account of the change in weight due to the loss or absorption of moisture.

*Color.*—The color of kieselguhr as it is received should be determined on a sample of approximately 150 mesh, both dry and moistened with water. Some information can also be obtained by comparing the original color of kieselguhr with that of ignited kieselguhr which has been heated above 1,000 deg. C. under oxidizing conditions. The color of the last-mentioned sample will be of value in determining the approximate percentage of iron oxide in the material and may be made upon the sample from the "Loss on Ignition," as will be outlined in the analysis of kieselguhr.

---

[6] C. Ellis: Hydrogenation of oils, J. I. & E. C., 5, 2, 95.

[7] Knolt: Technologic Paper 10 of the Bureau of Standards reports pure silica flows distinctly at 1750° C.

[8] Parsons: Fuller's Earth, Bureau of Mines Bulletin.

[9] Johresber: Chem. Tech. (1876), c. 22, p. 481.

*Apparent Density.*—In the case of pulverized kieselguhr a tared vessel is filled loosely with the material and the excess scraped off of the top by means of a straight-edge. The weight of kieselguhr divided by the weight of an equal volume of water gives the apparent density. In the case of blocks or bricks made of kieselguhr, this value is obtained readily by measuring and weighing the sample.

The apparent density is one of the most valuable and most readily determined of the physical properties of kieselguhr, and forms an excellent criterion for the approximate comparative efficiency of the product for many purposes.

*Fineness of Grain.*—A weighed sample is washed through the proper size screen with a fine jet of water, and the residue dried, weighed and the result expressed in percentage loss through the various sizes.

*Character of Grain.*—The shape and general character of the kieselguhr cells and the approximate amount of inactive or non-cellular material present may be readily determined by means of the microscope. The source of the material may often be determined by a microscopical examination.

*Absorption.*—A dried five-gram sample of kieselguhr is allowed to absorb a measured quantity of water from a burette until continued stirring fails to produce a pulverulent mass. The absorption coefficient is expressed in terms of cubic centimeters of water absorbed per gram of dried sample. The stirring should be done in a manner least destructive to the frail cells, grinding and crushing being avoided.

*Chemical Analysis.*—One-half gram sample is weighed in a platinum crucible, heated to redness to drive off organic matter, cooled, moistened with small amount of distilled water, about four drops of dilute sulphuric acid and one cubic centimeter of hydrofluoric acid added. Heat on a sand bath to fumes, and repeat the operation until decomposition is complete, after which the crucible is ignited strongly until constant in weight. The loss consists of moisture, organic matter, combined water and silica. Of these the moisture is determined on a separate sample at 105 deg. C. and the organic matter and combined water are determined on the same sample as "Loss on Ignition" by continued strong heating until constant weight is obtained. These values are then deducted from the complete loss, giving the silica content of the sample. The residue from the hydrofluoric acid treatment is fused with sodium potassium carbonates, dissolved in diluted hydrochloric acid, oxidized with bromine water and the hydroxides precipitated by means of ammonia which are filtered off, ignited and weighed. In the precipitate the iron, alumina and titanium oxides are determined by any of the well-known methods and the lime and magnesia determined in the filtrate.

### Kieselguhr Products

In selecting the most suitable kieselguhr product for use it is quite often possible that a number of the properties desired can be obtained from several of the products, and particular care should be taken to select the one which has the greatest applicability to the problem in hand.

*Natural Kieselguhr Blocks.*—Sawed natural kieselguhr blocks, when dry, are light, weighing approximately twenty-eight to thirty-five pounds per cubic foot. They are fairly strong, having a crushing strength of 400 pounds per square inch, and have an exceptionally high insulating value, as shown in Table I. Their melting point is 1,610 deg. C. (2,930 deg. F.), and are unaffected up to temperatures of a red heat, except for slight shrinkage. They can be sawed to almost any size or shape, and offer an ideal and highly efficient material for insulation of moderately heated bodies and for cold storage work. For very high temperatures, however, they have the disadvantage of shrinking and spalling.

*Pulverized Kieselguhr.*—The natural kieselguhr when reduced in a manner which does not destroy the structure of the diatoms is ordinarily supplied in many grades of fineness and weight suitable for any of the uses to which this material may be applied. The weight per cubic foot varies between eight and twelve pounds, according to the grade and state of division. The color of the various grades runs from pure white to light brown, depending on the percentage of impurities present. The silica content ordinarily runs from 80 to 90 per cent. on the dry sample. The material has a very high thermal and sound insulating value, and is used as a filler for a variety of purposes, as indicated above.

*Lightweight Kieselguhr Insulating Brick.*—When pulverized kieselguhr is treated and burned under proper conditions a lightweight brick is produced which has a very high insulating value, which is fairly refractory, and sufficiently strong to withstand considerable handling and transportation. In preparing this brick it is essential that the kieselguhr be treated in such a way as to retain its natural insulating properties as far as possible. It contains approximately 95 per cent. silica, has an apparent density of 0.70 or less and an approximate weight of 45 lbs. per cubic foot. A regular size building brick weighs approximately $1\frac{3}{4}$ to 2 lbs. While this brick is not adapted to highly refractory use on account of its shrinkage at high temperature, it can be used for insulating purposes up to a red heat without damage. On account of the fine grained texture of this brick, however, it is advisable to protect it from extremely sudden changes in temperatures. The compressive strength of this brick is about 500 lbs. per square inch. It is used principally as an insulating backing for more refractory brick.

*Kieselguhr Firebrick.*—Firebrick made of kieselguhr flint are acid, highly refractory brick of a much higher insulating property than any firebrick now on the market. They are used for building and lining high-temperature furnaces, kilns, boiler setting and general metallurgical work where a lightweight non-conducting, refractory brick is required. The apparent density of this brick is approximately 1.00; a standard size firebrick weighing about 3 to $3\frac{1}{2}$ lbs. The Bureau of Standards reports the melting point of this firebrick to be 1,650 deg. C. (3,002 deg. F.). The thermal conductivity has been found to be in accordance with the table given above. The crushing strength of this brick is approximately 1,200 lbs. per square inch.

Research Laboratory, Kieselguhr Company of America.
Los Angeles, California.

---

## Manganese Bronze

BY W. M. CORSE AND V. SKILLMAN

Prior to the final quarter of the last century it was well known that the addition of small amounts of iron to copper and its alloys had a decided hardening and strengthening effect. Its introduction resulted at the same time in producing some less desirable qualities, as, for instance, a decreased ductility.

In the constant search for something better, the introduction of manganese in place of iron was tried. Cupro-manganese was prepared by reducing pyrolusite or a purer form of manganese dioxide in the presence of copper. This alloy was then employed to introduce small amounts of manganese into brasses and bronzes. Some benefit resulted and the manganese brasses and bronzes met with favor for some time. The manganese acted as a deoxidizing agent, much as the later perfected introduction of phosphorus in bronzes does. There do not seem to be on record the results of any experiments which would give the comparative value of iron and manganese when introduced separately into brasses and bronzes.

It remained for P. M. Parsons, of London, England, to add both iron and manganese. As a result he was granted British Patent 482, February 7, 1876, for his invention. A sentence from the patent reads: "Alloys of copper and tin or zinc, or both, may be rendered more homogeneous, closer in texture, harder and stronger by adding thereto a proportion of ferro-manganese, spiegeleisen, or other carburet of iron containing manganese." It should be noted that his patent was simply for the introduction of iron and manganese into alloys of copper and tin or zinc, or both. No mention was made of any particular alloy at all similar to the special brass which is now quite universally termed manganese bronze. The addition of iron and manganese to a metal containing 90% of copper and 10% of tin (gun metal) which is a true bronze was mentioned.

In the United States a patent No. 206604,1878, which was a duplicate of the British patent, was granted to Mr. Parsons. These patent rights were controlled by the Manganese Brass & Bronze Company, Ltd., of London, England. They proceeded to manufacture several different metals containing iron and manganese as specified. The alloys ranged from those containing zinc much in excess of tin to others composed of practically copper and tin alone.

It was soon discovered that the manganese brasses or high zinc alloys were entirely unsuited for sand castings and could only be employed successfully for casting in metal molds. It was not long before they were discarded almost completely in favor of the manganese bronze, composed of copper, tin and manganese, which gained some popularity. The first castings, therefore, of propellers and the like, which were described as being made of manganese bronze, were cast from true copper-tin bronzes.

These bronzes were not subject to the same casting limitations as the brasses. They could be readily handled in sand, but on account of the greater cost of tin as compared with zinc they were more expensive than the brasses. The latter in the form of forgings, rods, wire, etc., had been shown to possess such desirable properties in regard to strength, ductility and the like that there seemed to be little doubt of their value in the form of castings if such could be successfully made in sand. This was later made possible by adding a small amount of aluminum to the manganese brass, and here begins the history of the now well known, but wrongly named, manganese bronze casting.

In 1888 Mr. Parsons was granted a second British patent (No. 11512, August 9, 1888) covering the addition of aluminum to the class of alloys mentioned in his previous patent. For some reason he seems to have failed to take out a duplicate United States patent for this. United States Patent No. 415832 was granted to A. H. Cowles, however, for the same idea.

With this knowledge at hand it was now possible to make sand castings from a cheap brass containing as much as 40 to 45%, zinc, which would have physical properties equal, or even superior, to castings made from the more costly bronze. Probably on account of the bronze-like properties of the newly discovered brass, a confusion in names resulted and until comparatively recent times, manganese bronze was used to describe both the tin and zinc alloys of the type under consideration. This also accounts for the great discrepancy for a time in statements regarding the physical properties of manganese bronze.

While progress was being made in Europe in the incorporation of iron and manganese in brasses and bronzes, the metallurgists of this country were not dormant. The effect of ferro-cyanide, ferro-manganese, manganese oxide and the like was being studied. A brass called "Vesuvius Metal," which contained both iron and manganese had been developed. It contained no aluminium and was found to be unsuited for sand casting. Shortly after, another brass called "Tubal Bronze" was evolved which was followed by Consol Metal and numerous other brasses of the same general character.

About 1893 the Manganese Bronze and Brass Company, holders of Parson's patent rights, licensed the rights for making Parson's manganese bronze in the United States. Since then many companies have undertaken the manufacture of this important alloy. There need now be very little uncertainty as to what is meant by manganese bronze. Practically all the best brands upon the market at the present time fall approximately within the chemical specification adopted by the American Society for Testing Materials which calls for an alloy containing 55 to 60% copper and 40 to 45% zinc with small amounts of iron, tin, manganese, aluminium, etc.

It will be noted that the alloy now recognized as a manganese bronze is in reality nothing more than a special high-zinc brass. The presence, however, of the metals other than copper and zinc is what places this highly valuable alloy in a class quite by itself. At the present time it is the principal non-ferrous alloy employed in the form of castings to any extent, as a substitute for steel. Its valuable physical properties are quite dependent upon the proper proportioning and alloying of the elements present in small amounts.

Commercially, there are two grades of manganese bronze now manufactured. One which is used for rolling and drawing is very similar to the old manganese brass and contains no aluminium. Its copper content is also slightly higher than the other grade which is used for sand castings. The latter contains aluminium. They are both manufactured in about the same way and a description of the method used in making material for sand castings would explain the process.

The first step in the manufacture is the preparation of the hardening or "steel alloy." This is composed of the iron, manganese, and tin which is to go into the mixture. Ferro-manganese is usually employed and the additional iron necessary is introduced in the form of wrought iron. Straits, or some other good grade of tin should be used.

The formula mostly followed is, approximately,

| | |
|---|---|
| 80% Ferro-manganese | 56.3% |
| Wrought iron | 12.5% |
| Tin | 31.2% |

By introducing the tin into this alloy the melting point is so much lowered that the otherwise difficultly melted ingredients are readily dissolved in the copper when the final bronze is made.

After a stock of hardener has been prepared the alloying of the bronze is proceeded with. The mixture commonly employed is as follows:

| | |
|---|---|
| Copper ingot | 55.0% |
| Zinc | 42.0% |
| Hardener | 2.5% |
| Aluminium | 0.5% |

A portion of the copper is melted and after being brought to a good heat the hardening alloy is added. This must be thoroughly stirred in and heating continued until it is entirely melted and alloyed. The aluminium is then added which causes a further increase in temperature, which insures the melting of the last traces of hardener. The remainder of the copper is then added and allowed to melt, after which the zinc is added. A good grade of zinc is necessary, as the lead present as an impurity in the poorer grades is very detrimental in the finished bronze. The whole is then thoroughly stirred, brought to the proper temperature and poured.

It is usual practice to cast the newly formed alloy into ingots and to remelt them to make castings.

If the preceding formulæ are followed a bronze should be produced which would fall within the specifications issued by the United States Navy Department, January 20, 1912, and which call for manganese bronze containing

Copper, 56 to 58 per cent.
Zinc, 40 to 42 per cent.
Tin, not to exceed 1 per cent.
Aluminium, not to exceed 0.5 per cent.
Lead, not to exceed 0.10 per cent.
Manganese, not to exceed 0.3 per cent.

As regards the physical properties of the above alloy, a test specimen properly cast in sand should give well over 70,000 pounds ultimate tensile strength per square inch, and at least 20% elongation in two inches. Some specifications also call for a minimum elastic limit per square inch, and a minimum reduction of area. The values given for these have been shown to depend to such an extent upon the "personal equation" of the operator conducting the test and upon the apparatus with which he is working that it would appear preferable to leave them out of future specifications.

Bronzes of various strengths and ductility can be produced by varying the percentages of copper and zinc and of hardener used in making the alloy. If more elongation is desired, less of the hardening alloy is added. A greater quantity of the latter would produce a stronger and harder alloy, but one with less reduction of area and elongation.

The percentage of the ingredients used in making the hardening alloy may also be varied slightly, as each plays a particular part. The iron, which is most important, increases the strength and raises the yield point of the bronze. The tin also increases the strength, but if present in more than a certain amount, also causes brittleness. The manganese acts as a deoxidizer and is considered by some as a carrier of the iron. Its presence causes the iron to alloy more easily at least. If sufficiently large amounts are added it has a strengthening and hardening effect similar to iron, but not as pronounced.

In making castings from manganese bronze when the alloy has been successfully prepared, the goal is still only partly won. It is generally conceded by founders that this alloy is one of the most difficult of the non-ferrous mixtures for the uninitiated to properly handle. The metal may be quite ruined by allowing it to remain in the furnace and overheat after it has been properly made. As a result of the high zinc content, its melting point is comparatively low, lying between 1400° and 1500° F., and therefore overheating or "burning" easily happens.

Chemical control is a necessity in handling this alloy if rigid specifications are to be continuously met.

The approximate production in the United States of this alloy is 1500 tons annually.

Buffalo, N. Y.

---

**Tin in the form of cassiterite** is found with gold in the gravel on Sullivan Creek, near Rampart, Alaska. In the richest spots the gravel will yield as much as half a pound of tin to the pan. This is equivalent to a value of about $18 per yard. Stream tin is worked in the York district where the gravel has a value of only $9 per yard.

---

# Federal-State Controversy Over Radium-Bearing Lands in Colorado and Utah

*[Editorial Correspondence]*

Interest in radium-bearing minerals in the United States has grown rapidly in the last year. Twelve months ago radium was considered largely of academic importance, but to-day the potential value of a genuine radium industry in this country is recognized, not only by those whose foresight has given the matter its present prominence, but also by technical men whose interests have been centered in other branches of mining and metallurgy. Federal and state officials are concerned as to the disposition of land containing radium-bearing minerals, and a strong sentiment is developing in favor of some means of securing for our country an adequate supply of radium from our own ores.

Colorado and Utah are the states most concerned. The deposits of radium-bearing minerals in these states have received careful attention from the Bureau of Mines, which has given welcome publicity to the whole matter of uranium, radium and vanadium in a preliminary report recently issued as *Bulletin* 70.[1] "The United States possesses unique deposits in these (Colorado and Utah) carnotite ores. They constitute at present the largest known supply of radium-bearing minerals in the world. With the exception of the ore mined and utilized by two firms, practically every pound is shipped abroad. Up to the present very little interest has been shown by Americans in these deposits, which may not be duplicated as to quantity in any part of the world. The only other large deposits of uranium-bearing ores known are those of Austria. They are considered of such importance that the Austrian government has taken entire charge of them. The output from the carnotite fields of this country is much larger than that from the Austrian mines and is likely to continue larger for some time to come, but the ore should be mined with minimum waste, and the industry should yield a maximum profit to this country."

In the light of these facts it is not surprising that our deposits have attracted the attention of European buyers, and that scientists and government officials in this country should become interested in exploiting them in such a way as to produce first an adequate supply of radium for domestic use, without undue prejudice to the needs of foreign countries. The private organization of the National Radium Institute in this country was a step in that direction.

## The Controversy

A proposal on the part of the government to withdraw the Colorado-Utah carnotite deposits from private entry has precipitated a storm of criticism, particularly in Denver, against a further exercise of federal conservation of the states' resources. Colorado's commissioner of mines has been particularly active in creating a sentiment of opposition to such an action. It is argued that federal interference at this time, when the mining and treatment of carnotite promises to become an important item in the state's mineral industry, would be most unfortunate; that it will retard the development of the state; deter further prospecting; limit the employment of miners and freighters, and generally act as a bar to progress.

Another argument by the state is that the greater portion of the carnotite produced is now used by domestic companies, and that a needless cry is being raised against exportation of ore to foreign countries.

---

[1] Further reference to production and exportation appeared in this journal December, 1913, pp. 673-4.

The "foreign invasion" is regarded as a myth and dismissed as a fancy of ultra-conservationists. A further point raised is this: If the government withdraws radium-bearing land from entry what is to prevent an extension of that policy to mineral land containing gold, silver, lead, zinc and copper.

It is plainly the fear of the state authorities that an act of withdrawal will result in unnecessary delay in the final disposition of the lands, and that a condition will be created similar to that which has existed in Alaskan and Western coal lands. There is also a feeling that more rapid development will take place under conditions of free prospecting by individuals than under government supervision and control. In short, the attitude of the state in this question is but an instance of the general opposition in the West to federal conservation as exemplified in some previous cases.

### What the Government Proposes to Do

The other side of the question has not been as thoroughly ventilated, and much of the state's criticism has been made without a knowledge of the details of the government's true proposal. The withdrawal of the land in question has been considerad for some time, but the proposed method of doing it has only recently been announced. Strong opposition developed, even among federal officials, against the usual procedure of withdrawal under the Land Office regulations; for while tho act of withdrawal would be a simple matter and quickly done, the more important matter of immediate exploitation of the deposits would not be so easily accomplished. The production of radium was recognized as being of prime importance, not only to the states containing the mineral deposits, but also to the entire country.

The plan finally proposed can be given best in the words of the Secretary of the Interior, in a letter to Congressman Foster, chairman of the House committee on mining: "The Secretary of the Interior should be authorized (by Congress) to conduct explorations and researches with a view to determining the practicability of developing from such ores (carnotite) a supply of radium, and also authorized by lease or otherwise to provide for the mining and treatment of radium-bearing ores in such manner as would best secure a supply of radium for the use of the government of the United States and the hospitals of the country."

An analysis of this statement will reveal intentions quite different to those assumed by western mining men. The significant parts of the statement are that the Secretary seeks authority "to conduct explorations and researches," and to "lease or otherwise provide for the mining and treatment of radium-bearing ores." The mere withdrawal of land from entry, without automatically providing for mining and treatment of ore, would be intolerable; and any resolutions on this subject passed by Congress should carry adequate and proper provision for exploration, mining and treatment, either by lease to private parties or through governmental agency, probably the Bureau of Mines.

There are arguments on this side of the question, as on the other. Those who favor the proposed federal plan contend (1) that the states (Colorado and Utah) will benefit by the activity of the government; (2) that no present owners or operators of radium-bearing land will be injured; (3) that the production of radium is such a marked exception in the mineral industry as to be entitled to special consideration from the government; (4) that more active and intelligent prospecting will be done under government supervision; and (5) that an adequate supply of radium for this country can be obtained most quickly and cheaply through governmental agencies.

Practically the only persons who can be injured under this plan are future prospectors, but even they can profit by making special effort to locate claims pending final action by the government. Up to date comparatively little prospecting has been done on personal account. Most of the work has been done by paid agents of the large companies, and even this has been confined to locating claims on which outcrops were plainly visible. Such deposits are now privately owned and the ores can be sold when and where the owners wish. Prospecting and exploration on a systematic basis might develop further deposits; but in view of the physical difficulties attending such work in those parts of Colorado and Utah containing the carnotite deposits, few individuals have undertaken to prospect; but even they could not do the work on a scale anticipated by the government.

Undoubtedly great pressure has been brought to bear on the government, through medical societies and other agencies, not so much to prevent the exportation of radium ore from this country, as to produce as soon as possible an adequate supply for domestic use. A great deal of such ore is going abroad, and one unfortunate feature of this is that American users can buy but little of the radium produced from their own ores, even at the rapidly rising speculative prices. The government stands for the local production of radium, possibly at Denver or some suitable western city, for the purpose of supplying the material at a price fairly commensurate with the cost of production. This would eliminate the speculative feature of present prices which have practically doubled in the last year. The government would be able to control only such new deposits as it might purchase or discover by exploration, and only such ore as it could buy from present claim owners. There would still be a comparatively large quantity available for purchase by foreign concerns.

### A Case for Cooperation

No ultimate good can come of a prolonged fight over this question. It is a time for coöperation of the different interests. All of the facts should be considered on their genuine merits, to the end that this country may take advantage of what appears to be a wonderful opportunity. The West will profit in any event; but the circumstances of the case are such that it should profit in a way that will be a credit to the whole country. If a fight is precipitated in Congress it might result in a mere withdrawal of the land without financial provision for exploiting it, which would be a most unfortunate outcome. If the states should wage an unsuccessful fight on the matter of withdrawal, they would then be in a poor position to influence congressional appropriation for mining and treatment.

The daily press has been filled with a lot of senseless twaddle and half-truths on this subject, some of which is plainly inspired by personal interests or born of political necessity. It serves no useful purpose, but tends to create false impressions. No satisfactory settlement of the proposed conservation can be reached without a knowledge of the whole truth.

The type of conservation which has found acceptance in this country is that which utilizes our resources to meet present needs without undue waste. Perhaps the matter of producing radium is a case in point. The element already has proved a wonderful therapeutic agent. The demand exceeds the supply. We have the raw material and we ought to make the best use of it now. Hence the legitimate opposition to a withdrawal of the land containing it, without automatically providing means for proper exploration and the ultimate production of radium for domestic use.

# Handling the Raw Materials at the Iron Blast Furnace

BY J. E. JOHNSON, JR.

*(Concluded from January issue, page 53)*

### Design of Bins

We can now turn to the bins which serve for storage of the raw materials going immediately into consumption.

These bins are of many types, bins having had a development covering many decades. Substantial and well designed wooden bins were in use at a few plants thirty, forty and fifty years ago. But the great storage required for modern plants necessitated one and frequently three or four tracks on top of the bins, all of which must carry the most heavily loaded railroad equipment. This, with the excessive maintenance of wooden structures, has gradually forced the introduction of steel bins, built as an integral part of the structure which supports them and the railroad tracks at the same time. Recently concrete bins also have been used.

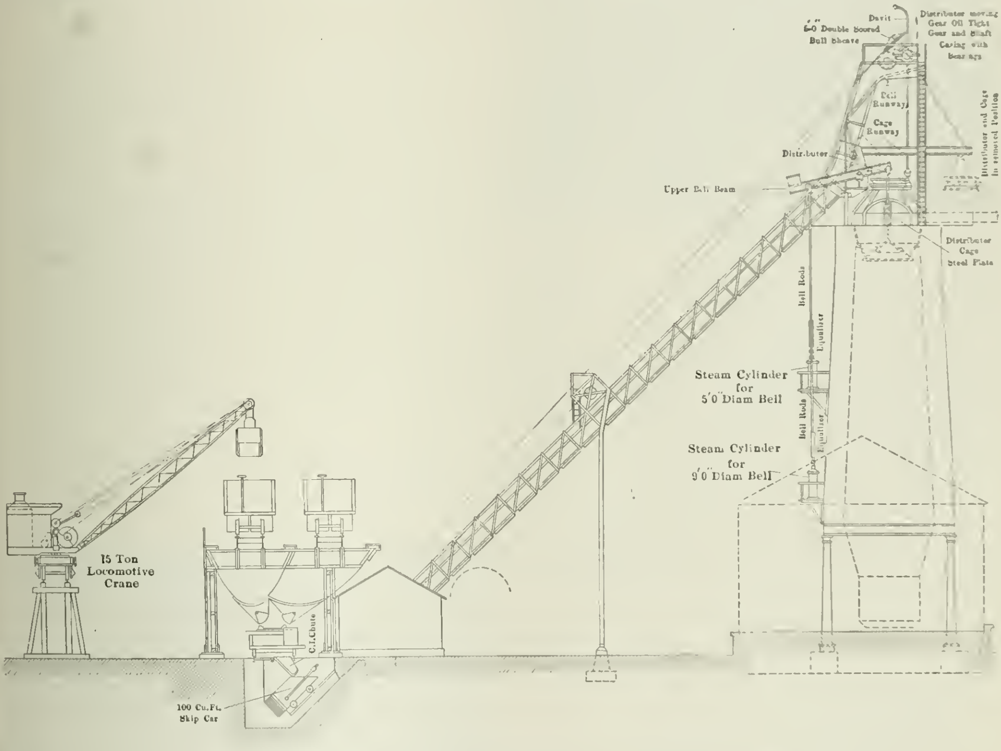

Davit
6'-0" Double Scored Bull Sheave
Distributor moving Gear Oil Tight Gear and Shaft Casing with Bearings
Bell Runway
Cage Runway
Distributor
Distributor and Cage in removed Position
Upper Bell Beam
Distributor Cage Steel Plate
Bell Rods
Equalizer
Steam Cylinder for 5'0" Diam Bell
Bell Rods
Equalizer
Steam Cylinder for 9'0" Diam Bell
15 Ton Locomotive Crane
C.I.Chute
100 Cu.Ft. Skip Car

FIG. 16—FURNACE WITH BROWN SKIP HOIST AND PARABOLIC BINS

It is useless to try to illustrate all the types of bins which have been used, and I shall therefore show only three of the best known types, which are brought out by the three concerns whose ore-handling machinery has previously been described.

It is necessary to explain that at the large modern plants where equipment of the highest type is used, mechanical filling is now practically universal, and these bins are not therefore designed to discharge into filling barrows, but into the modern successor of the filling barrows, the scale car.

The design of gates for bins is a matter the difficulty of which in practice is as great as its simplicity appears to be on cursory examination. The material to be handled is irregular in size, irregular in shape, rough, as likely as not to be sticky, and more likely than not to have its coefficient of friction greatly altered by a change from dry to wet. If the gate opens and closes from above, guillotine fashion, it may just happen to catch the largest lump passing, which may be too strong to be crushed, and holding the gate open will leave room for a rapid flow of finer material under it. If the shape of the chute be not right the material will jam and bridges exercising apparently almost human, not to say devilish ingenuity, in building an arch which quickly cuts off the flow of material from the bin, and which cannot be broken outward because the material is under compression, nor inward except with the greatest difficulty because the pressure of all the material in the bin lies against it.

More than one case is on record where an engineer or furnace manager has designed a new type of gate for a bin, taken a guest out to see how beautifully it operates, and then had it fail so completely that the filling barrow, or even the scale car, would be buried up because the material could not be shut off when the "improved" gate was brought into play.

Even if these fundamental difficulties be overcome great care is necessary in placing the spouts on the bins and bringing them sufficiently close together so that material does not build on the space between them and in time almost fill up the bin. This may seem like an extreme statement, but I have seen bins of the very best construction and most carefully designed, which looked to be full of ore, but on a closer examination two holes, three or four feet in diameter, were to be seen running down from the top to the two chutes below. These holes would represent almost the only free-flowing capacity of the bin. The ore being plastic and sticky, had built up upon the base of the bin and the bridge between the spouts, until the capacity of the bin was almost gone. This is likely to happen to some extent with any design, and the only way to meet the situation is to dig the bin out at frequent intervals, as the rapidity with which the ore builds is increased as it gets a larger and larger foothold.

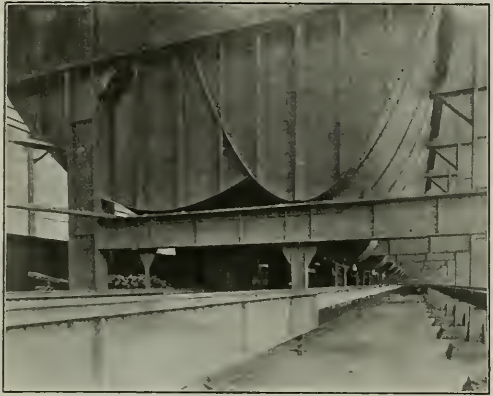


FIG. 17—PARABOLIC BINS

It was with the object of overcoming these various difficulties and furnishing bins whose flow would be under the absolute control of the operator that the three designs now to be described were brought out.

Taking the designs of the three builders mentioned in the same order as before, Fig. 16 shows a "parabolic" bin designed by the late Alexander E. Brown, of which the principle is taken from the fact that when a liquid or semi-liquid is suspended in a trough of flexible material, the cross section assumed by the trough is a parabola, therefore by giving the bin this shape, stresses tending to deform it are eliminated, and only its weight needs to be considered. These bins are suspended from heavy girders, which in turn are supported by steel columns. The complete parabola at the left is for ore. The incomplete one of greater width, on the right, joined to the ore bin at the left, is for coke.

The spouts on these bins with their gates in the form of cylindrical quadrants are plainly shown at the bottom, as is also the scale car beneath them. A locomotive crane standing on an adjacent trestle, and in a position to discharge ore into the railroad car standing on the bin trestle, is also clearly shown.

The construction of the bins is well shown by the photograph (Fig. 17).

Fig. 18 shows the bottom of the bins with their chutes, also the scale car and its operator. It will be seen that the quadrant gates are operated by a pair of connectng rods attached to crank pins, carried on a heavy gear shaft, supported at the top of the chute. The large gear is driven by a pinion which in turn is driven by a pair of beveled gears. From the vertical shaft of the driver of these depends a shaft carried by a universal joint and carrying a socket at its lower end. The scale car carries a square-headed shaft, which can be thrown up by the operator to engage with the socket for any chute. After this is done a small motor is started and the gears revolved until the crank pins come to the bottom position, at which time the gate is wide open. When the required amount of stock has been drawn the gate is raised by revolving the large gear shaft through another half revolution.

The style of bin and chute designed by Hoover & Mason is shown in Fig. 19. No attempt is made in this bin to use the parabolic shape, which is open to the objection that its angle changes, so that while it may be steeper than necessary in some portions it is flatter than necessary in others, and the latter condition prevails near the bottom, where the flow should take place most freely.

The bottom of the bin is formed by a horizontal roller five feet in diameter which lies close to the bottom edge of the chute, so that no material can get between the two. This can be rotated at the will of the operator in the direction shown by the arrow. The angle from the top of the chute opening in the bin to the top of the roller is considerably less than the angle of repose of the material, so that no material can possibly get out of the bin when the roller is stationary. On the other hand, when it is rotated the material is carried forward by the roller to a point at which its slope is greater than the angle of repose of the material, which then slides off. When the roller is stopped the flow of material instantly ceases.

The front of the bin is built with louvre with a reverse slope, through which it is impossible for the material to make its way out, but through which it is very easy for the operator to thrust in a bar and break any bridge or arch that may form to obstruct the flow.

The roller is driven by means of gearing thrown in by a clutch worked by the operator. The gearing is actuated by a line shaft or driving shaft, which runs continuously. There is a separate roller for each discharge, the equivalent of each chute in the older type of construction, and the design is such that the ends of these rollers come very close together, leaving a mimimum of space between them, so that the bin is practically open at the bottom all the way along. This to a great extent prevents the formation of accumulations of ore, as these have no foothold on which to begin to form, the bottom of the bin being kept clean by the continuous sliding of the material over it, and no bridges between chutes existing. For the coke bin the roller is perforated, and by an ingenious arrangement made to serve as a screen for the removal of the fine material from the coke. This action is always complete and automatic because the roller cannot run as a feed device without also acting as a screen.

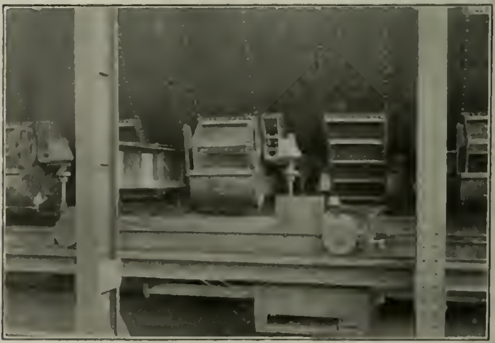


FIG. 18—BOTTOM OF BROWN HOIST BINS WITH THEIR CHUTES, AND SCALE CAR WITH OPERATOR

The transfer car used in bringing the ore from the

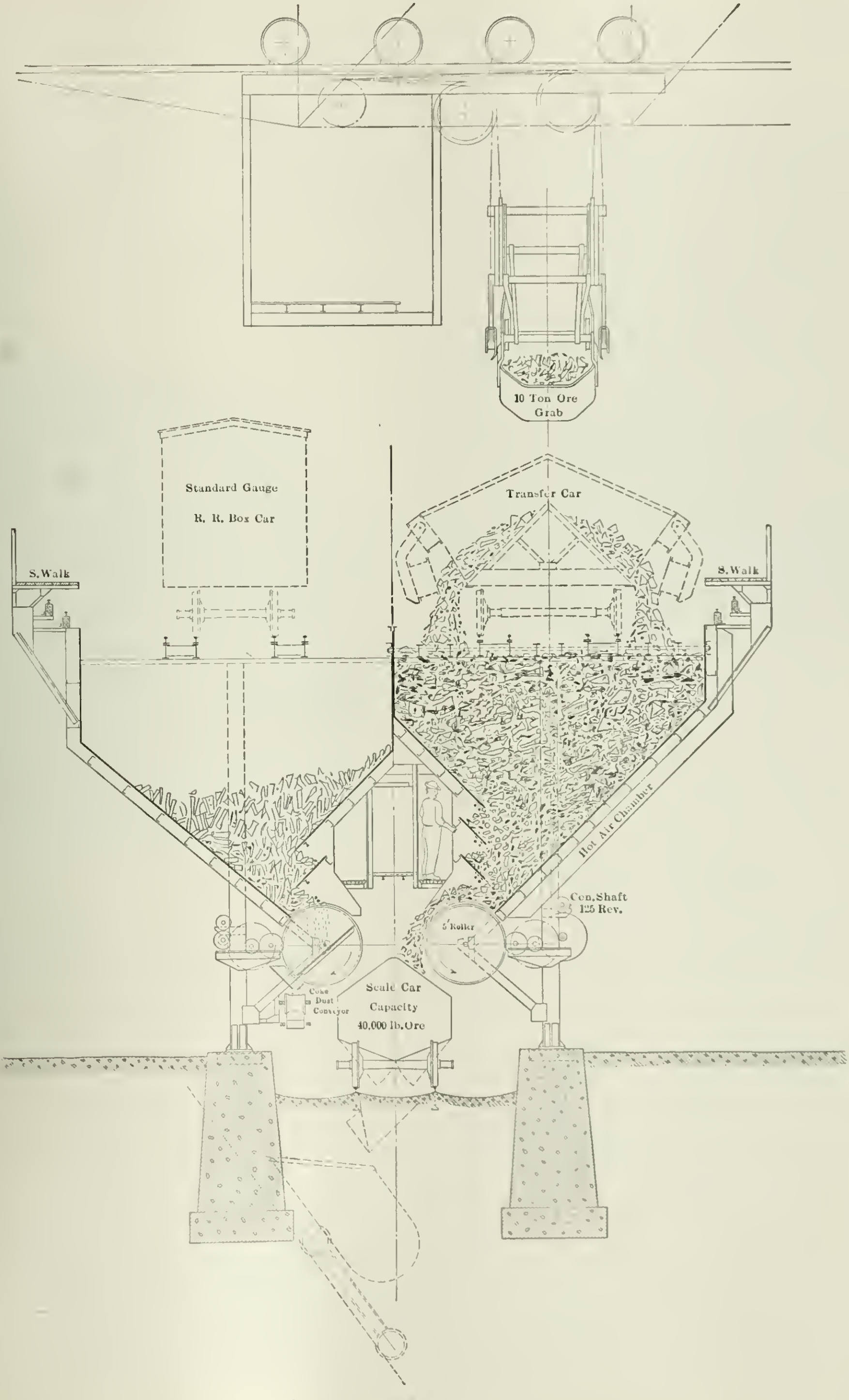


FIG. 19—HOOVER & MASON BIN AND GATE

bridge to the bin is shown in dotted lines above, as is also the overhanging end of the ore bridge with its grab bucket and trolley.

A gate has been introduced by the Wellman-Seaver-Morgan Company, which is on the same principle in all particulars as that of Hoover & Mason except that the former use an endless belt made by overlapping metal slats mounted on sprocket chains, as shown in Fig. 20, instead of a roller. The pressure of the stock on top of this is taken by beams lying inside the endless belt, on which the upper half of the belt slides. Owing to the location of this apparatus up underneath the bottom of the bin, the construction is not as clearly shown by the photograph as might be desired, but the overlapping metal slats and the sprocket chains are visible, and the operation will be understood from the description of the Hoover & Mason apparatus. The metal belt acts as a bottom to the bin and carries the material bodily forward until it drops over the driving-sprocket end into the scale car.

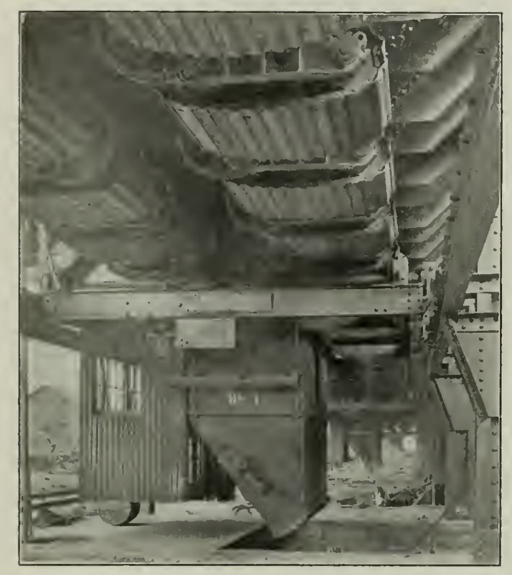


FIG. 20—WELLMAN-SEAVER-MORGAN GATE—ENDLESS BELT MADE OF OVERLAPPING METAL SLATS ON SPROCKET CHAINS

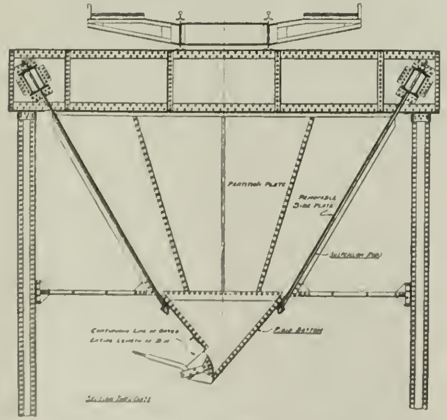


FIG. 21—HEAVY STEEL "BAKER" SUSPENSION BIN WITH HAND-OPERATED QUADRANT GATES

It will be noted that all three of these designs which jointly have probably been applied to a greater tonnage of bin capacity than all other types combined use power for the operation of the gates.

This is because of the difficulty that has often been met in operating hand gates quickly and positively, to which I have already alluded. At the same time it must be understood that many hundreds of bins are in successful use with hand-operated gates, which have the advantage of greater simplicity and lower first cost than any of the power-driven gates.

Fig. 21 shows an outline drawing of the Baker suspension type of bin built by Arthur G. McKee, Contracting Engineer, Cleveland, Ohio. The gate in this type of bin is a quadrant of a cylinder, but in the reverse position to that used on the Brown bin. The axis of the cylinder is so located that the flow of the material tends to close the gate, so that it is not liable to be opened accidentally. The gate is operated by the scale-car operator through the lever shown in the drawing.

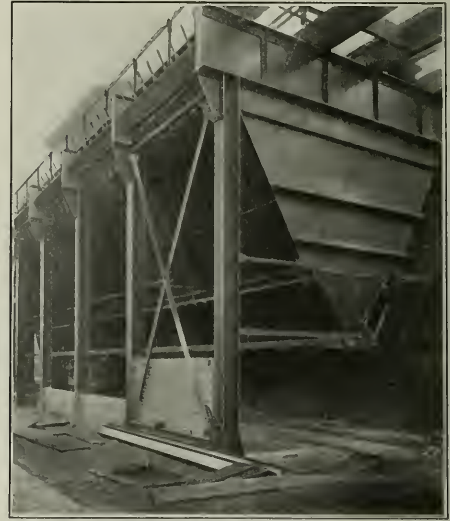


FIG. 22—MC KEE-BAKER SUSPENDED BIN WITH CONTINUOUS LINE OF GATES, HAND OPERATED

Owing to the absence of machinery these gates are only separated from one another by the small space necessary for clearance, so that the opening in the bottom of the bin is continuous and the formation of bridges and building up of the ore inside the bins is thereby to a great extent prevented.

These bins are, like the Brown, of the suspension type, but instead of their cross section being that of the true parabola it is made up of four tangents thereto, which give to a large extent the same freedom from distortion that comes from the use of a true parabola, any minor stresses of this nature being taken up by the transverse partition plates and the rigid bottom.

A considerable tonnage of these bins is in successful operation at various plants and there are many others with other types of hand-operated gates, many of which are entirely successful.

### Methods of Hoisting in Mechanical Charging

In hoisting for mechanical filling, as apart from distribution (the latter being used in the technical sense of distributing the stock properly in the top of the furnace), there are two main systems in use to-day, and a third which is a combination of some of the features of each.

In the first system the stock is drawn from the bins into large round buckets, whose bottoms consist of a cone, or "bell," attached to a rod running up through the center to a hook at the top. This bucket is then transported to the bottom of the hoist and sent up, hanging by the hook at its top, to the top of the furnace, on which it is seated and then dumped by lowering the hook on the central rod carrying the bell, which is merely a large conical valve. In this system the material does not break bulk from the bin to the furnace top.

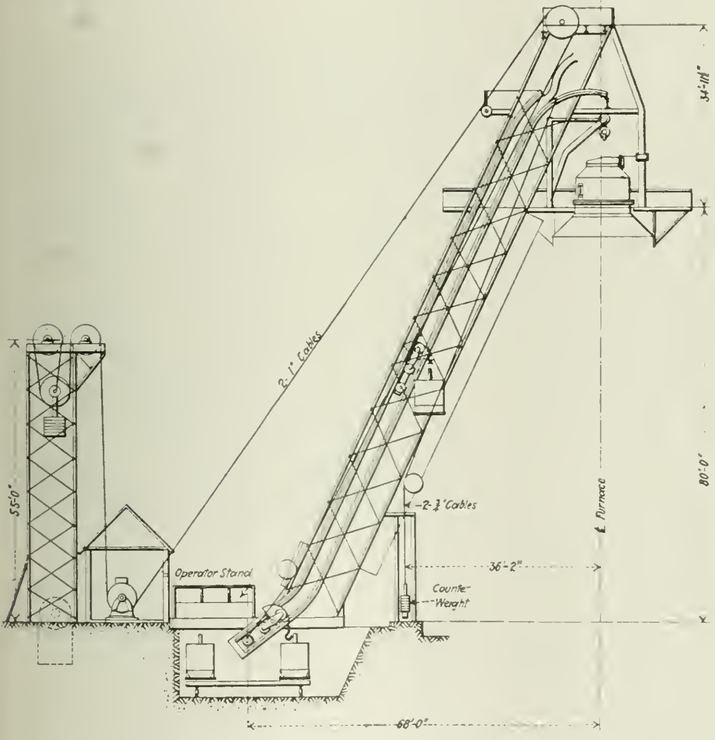


FIG. 23—FORD-PARKS SYSTEM OF BUCKET FILLING

Different systems of rotating the buckets are in use, but this subject can more appropriately be discussed under the head of stock distribution. Various methods have also been used for lowering the bucket onto the furnace top after it reached the proper position. But while these differ from the one illustrated, they do not differ sufficiently in principle to make detailed description necessary.

In the other system a sort of tank, either rectangular, round or elliptical, with wheels on one side, runs from a pit beneath the filling level to a hopper above the furnace top, where it turns upside down and dumps, then returns to the bottom, its travel being thus confined entirely to the inclined track running to the furnace top, known as the skipway, the tank itself being known as the skip.

This skip is usually filled from a motor-driven dumping car, with its body or dumping hopper mounted on a scale carried by the truck, called the scale car or larry. This car is traversed along in front of the bins and filled from them. It is then returned to a hopper or chute, which delivers into the skip when the latter is in its bottom position, and there dumped, returning for another load while the skip is hoisted to the furnace top.

In this system it will be seen the stock breaks bulk between the bins and the top of the furnace.

At some plants a combination of these systems is in use, in which the bucket with the bell bottom is never removed from the suspension truck on which it is carried, or only to a turntable serving it, and plies therefore only on the incline, being filled by a scale car exactly the same as a skip. The bucket in this case virtually becomes a skip which dumps through the bottom while retaining its upright position, instead of being turned upside down, as is done with the regular skip.

The first type of distribution is shown in Fig. 23, which shows the Ford-Parks modification of the original Nieland top.

The second of these styles of hoisting is well shown by Fig. 16, which is the design of Alexander E. Brown, and with which in connection with the distribution at the top of the furnace we shall deal more at length later.

Many variations of each of these systems are in use. Very frequently in the case of the skip hoist the coke bins are arranged on each side of the skipway, and coke is spouted directly into skips without the intervention of the scale car, the bulk of the coke being taken by skipfuls instead of its weight. This is a very satisfactory system if the same coke is always used, but one liable to produce great derangement of the furnace if sudden changes are made from one coke to another of very different density.

The skip hoist is built with both single and double skips. The advantage of the double skip is that it is perfectly counterweighted, without extra mechanism for that purpose, and that it has a very great capacity. It, however, labors under the disadvantage that it discharges the stock at two points, one each side of the central plane, rather than at one point exactly in the central plane, as is done with the single skip.

Where the irregularities of the distribution are not compensated or eliminated by suitable means, the lack of symmetry, due to the fact that the skips dump on opposite sides of the main central plane and on the same side of the central plane at right angles to it, is likely to cause very serious derangement of the working of the furnace. The elimination of these irregularities is made much easier if the skip dumps exactly in the central plane.

A double skip was put in use at the Pueblo plant of the Colorado Fuel and Iron Company a number of years ago, designed by Mr. E. G. Rust, in which the advantages of both the single and double skips were obtained by a most ingenious design. Both skips run in the central plane and occupy the same positions at top and bottom. Of course when one is at the top the other is at the bottom, and there is no fouling in those positions, but in order that they may pass each other the tracks diverge from one another in the vertical flumes starting from the top and bottom so that they are separated vertically at the middle of the skip bridge by a sufficient distance to allow the under skip to pass beneath the upper. The gauge of the track for the upper skip is wider than that for the lower, which runs between the rails of upper track. The deepening of the skip bridge at this point tends to give it additional strength at the place it is most needed.

This system has been in use at the Pueblo plant for a number of years, but for some unknown reason its use has never extended very widely.

### Location of the Hoisting Sheaves

One of the difficulties met in skip hoist design is that commonly the hoisting rope must run over a sheave located at the upper end of the skipway and come back over the top of the skip in order to be out of the way of the stock when the skip dumps. This brings the rope above the skipway while the hoisting engine is generally most conveniently located underneath the skipway.

Various arrangements have been used to overcome this difficulty. In one design a truck is used which carries the skip at its upper end and practically pushes it up the incline, the skip being pivoted to the truck and having an auxiliary pair of wheels in the front. In this case the sheave is put below the skipway and is far enough below the skip when it dumps to be out of the way. This puts the rope under the skipway where it is most desirable to have it.

In a number of cases the ropes have been carried clear over the top of the furnace, and the hoisting engine placed on the opposite side in order to overcome this difficulty, while in one well known type of top two guide sheaves are used on each skip rope, in addition to the main hoisting sheave, in order to get the rope out of the way at the top and pass it back underneath the skipway.

In the Brown design of skip hoist the difficulty is solved by the use of the single skip, and by putting the hoisting sheave in a plane parallel with the skipway as shown in Fig. 16 so that the hoisting rope can be returned over one side of the skipway to the engine house beneath it.

Probably other solutions of this apparently trivial problem have been attempted or made, but these are the ones best known and most used.

### Dumping the Skip

The method for turning the skip over to dump is universally the same. The main rails of the skipway bend down from the incline and run in level when they reach the top of the hopper, but there are two additional rails set to a somewhat wider gauge which continue on in the main line of the skipway. These are set far enough apart so that the front wheels can pass through them without touching the wheels, all being outside the skip. But the rear wheels have a supplementary tread outside the regular one, which comes onto these supplementary rails just where the main rails bend down from their straight line. This carries the rear wheels on up while the front ones go forward on a level line, and in something less than twice the length of the skip it is turned up to an angle of forty-five degrees or more and so emptied completely.

### Counterweighting

The bucket type of filling must use a counterweight in order to avoid excessive consumption of power, and somewhat more difficult control in handling its loads, because from the nature of the case the bucket type of filling must be of the single-hoist variety and therefore unbalanced.

Various methods of arranging the counter-weight are in use. Very generally a vertical tower is used of somewhat less height than the furnace, in which a weight is raised by the counter-weight rope, when the skip is going down. A system of sheaves is used like an ordinary block and tackle in order to get the required counterweighting effect with a short travel by using a proportionately heavier counterweight.

The Brown skip hoist when designed for a single skip eliminates the problems of reversing the engine and of counterweighting the skip by using a hoisting engine in which the drum is connected to the engine shaft through a friction clutch under the control of the operator instead of the ordinary hoisting engine in which the drum is keyed to its shaft and positively connected to the engine shaft through gears. The engine runs always in one direction and the skip is hoisted by throwing in the clutch. On the return trip the skip is allowed to run back by throwing out the clutch and controlling the drum with a brake.

The better type of engine which can be applied by eliminating the need for reversing makes this system more economical, in spite of its loss of power in hoisting the unbalanced skip, than the ordinary system is with the skips balanced, but using the very uneconomical type of reversing engine previously described. The Brown system, however, is open to the objection that it requires some skill on the part of the operator in throwing in and out the clutch and lowering the skip with the drum brake, whereas the counterweighted system can be made entirely automatic as to control, etc., by the use of the slow starting and slow stopping devices previously described.

### Larry Cars

These are almost always used with skip filling and sometimes also with bucket filling. Their essentials are in general always the same, but the details of their arrangement varied greatly. These essentials are a truck, motive power for the truck; a buffer with quick and complete means for discharge and scales supporting the buffer on the truck.

Frequently also there are means for operating the gates. Several of the preceding illustrations of bins have shown scale cars also and from these a good idea of the standing types may be obtained. They may be either of the suspended type with their rails elevated close up under the bottom of the brim which has the advantage that nothing can fall from the chute or buffer onto the rails; or the rails may rest on ties on the ground as in standard railway track.

Many systems of discharge scales have been used and in general the details of the design of these cars is adapted to the conditions of the individual case and the judgment of its designer.

A modified type of larry is used with the original bucket type of filling in which the buckets are removed from the hook of the hoisting truck and taken directly to the bins to be filled, but in this case the more appropriate name of scale car is used.

These differ from the larry principally in having a platform in which the bucket rests instead of a buffer; while, like the larry, their detailed design is adapted to the condition of the given case.

### Scales

One of the most important details of the whole operation of charging a furnace, which as a whole is probably the most important single part of blast furnace operation, is the weighing of the materials. It is customary to look upon the blast furnace as a rough, not to say crude apparatus. This view is justified in part by the enormous forces which it must handle and keep under control. But as a matter of fact in spite of its size it is one of the most sensitive pieces of apparatus in industrial use and runs on smaller margin of safety in fuel than any other of our great industrial operations. Changes of the "burden" (a technical name for the weight of ore for a given fuel charge) as small as one per cent are not infrequently used in adjusting the operation of the furnace to make the kind of iron desired with a minimum consumption of fuel. Changes of two or three per cent are as large as are often made to adjust for the ordinary variations of operation. Such adjustments necessitate accurate weighing, and the lack of this has often been accountable for bad furnace operation, and even more numerous cases in which claims of remarkable furnace work were based upon inadequate or incorrect knowledge of the weights of the different materials actually used. Not infrequently the consequence has been a bitter disappointment when the book inventory of the material on hand was compared with the actual stock of such material.

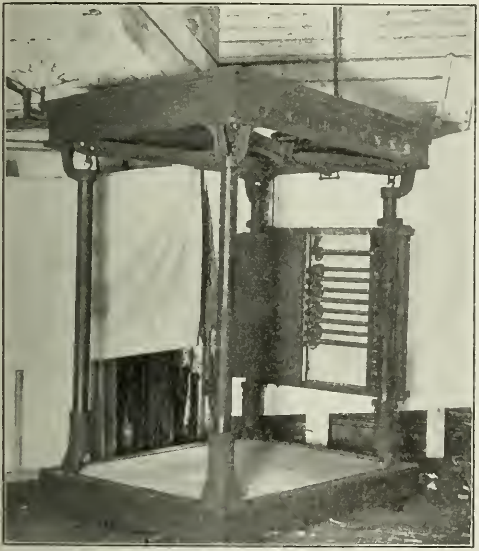


FIG. 24—FURNACE CHARGING SCALE

Cases are on record too numerous to mention in which the books have shown the presence in the stock house of thousands of tons of material, and the financial returns have been estimated on this basis only to find on investigation that the material, so plainly shown by the books, had been put through the furnace and was conspicuous by its absence from the stock house. This has sometimes happened with the knowledge, or even through the deliberate action of a dishonest superintendent, but has also often happened to an honest one who had too great confidence in his scale weights. This condition is now so well understood that the financial management generally insists on a monthly or weekly inventory of the actual material on hand, and its comparison and reconcilation with the figures taken from the furnace books.

The scales used for charging purposes have to meet certain special conditions, and therefore were early designed by the scale makers for this purpose, and given the name of "charging scales."

The type of these in common use with the barrow system of filling is shown in Fig. 24 (Fairbanks & Co.). These are platform scales with the base sunk in the floor of the stock house so as to bring the platform level with the floor. In recent years these have nearly always been of the suspended type, the platform being carried by four suspension rods from the scale-levers over head. This takes the latter up out of the way and out of the dirt in which they were necessarily more or less buried with the older type of scales, in which the levers were in a pit below the platform.

A special condition that these scales have to meet is that as a general thing at least three kinds of material have to be weighed—fuel, ore, and flux (limestone or dolomite), and a definite amount of each is required for each charge.

In order to meet these conditions the scales are built with from three to six separate beams, any one of which can be lifted up out of operation or lowered onto a frame depending from the main beam, so that the two operate as one. The main beam is usually used to balance the weight of the empty barrows, and one of the secondary beams is then thrown in for each material to be filled, its pea being locked fast for the charge weight wanted, this particular beam then rises and falls according to the weight of the given charge in the barrow. When this has been adjusted by adding or subtracting material this beam is thrown out and that for the next material thrown in.

The introduction of mechanical filling brought about the necessity for a different arrangement of the scales, and the trucks which carry the buckets to the bins in the bucket system of filling are provided with scales under the platform on which the bucket rests; or in the case of the larry car used with the skip, the hopper is carried directly by the scales which constitute a part of the truck. The same system of beams has in some cases been used as in the stationary charging scales, but in more recent years it has been found extremely desirable to use a recording type of scale.

The first of these ever installed, so far as known to me, was built by the Streeter-Amet Company of Chicago, for the order of Mr. W. L. Kluttz, now vice-president and general manager of the Central Coal and Iron Company, then superintendent of the Thomas plant of the Republic Iron and Steel Company.

This scale carries a large round dial, around which a pointer travels as the weight on the scale increases. Certain fixed markers are attached to the face of the scale, in positions corresponding to the burden of the different materials wanted, and the scale car operator can then watch the gradual rising of this pointer toward the desired weight, so securing much more accurate weights than is possible when the only indication given by the scale occurs during the brief instant while it is in balance, since then it is generally overloaded before the supply of material running in can be cut off.

These scales are also provided with a paper tape, and by means of a lever, which is pulled when the correct point is reached for each portion of the charge, the actual weight on the scales is stamped on this tape, which is locked up in the scale box, entirely inaccessible to the operator. At any interval desired, generally once a day, this tape may be taken out and examined to see the accuracy of the weights actually obtained, as compared with those called for by the pointers.

The moral effect of this on the scale car operator is tremendous, and vastly better results can be secured by the use of such an apparatus.

The writer became general superintendent of the plant mentioned between the time that this experimental apparatus was ordered and the time it was put in operation. The change produced in the accuracy of the weights obtained was almost beyond belief and the work of the furnace on which the scale was used immediately improved very much.

Since that time the American Kron Scale Company has brought out a similar device by which the same results may be obtained. The practical importance of this matter is so great, and the moral effect upon the scale car operator caused by the knowledge that a continuous record is being made of the way in which he is doing his work, are so important that it is doubtful if any furnace is justified in doing without such equipment.

The scales on scale cars are subjected to a very serious service. They not only have to receive the impact and shock of the incoming material, but they have to stand the much more serious shocks arising from irregularities in the track on which the scale car runs. The great inertia of the charge on a loaded scale car causes enormous stresses on the knife edges even with apparently insignificant irregularities in the track. For this reason switches, cross-overs, and other breaks and irregularities in scale car tracks should be avoided to the greatest possible extent. Moreover, these cars should always be provided with springs over the axle boxes, or in other suitable location. These springs should be the softest, that is, have the maximum travel for a given change in stress, permitted by the conditions, as in this way the springs absorb the shocks arising from the irregularities of the track and keep them off the knife edges.

I have seen scale cars built entirely without springs, and at the same time heard the furnace managers complain bitterly that it was impossible to get his scales to stand up and give accurate service, without his realizing the reason.

Means have been provided whereby the weight of the charge hopper was lifted off the knife edges except during the time that it was actually being weighed. But it is ordinarily difficult to get scale car operators to use this device. There seems no reason why it should not be made to interlock with the traversing motor of the car, so that the latter could not be moved except after relieving the knife edges of the scales from weight.

This may seem a matter of too little moment to deserve such serious mention, but when the importance of accurate weighing previously mentioned is considered, and when it is realized how utterly unreliable the best scales become when their knife edges are even slightly worn, it is believed that the stress laid on this subject will be justified.

## Electrochemical Progress in Norway in 1913

Mr. I. J. Moltkehansen, Managing Director of the Fredriksstad Elektrokemiske Fabriker A. S., communicates to us the following notes which will we assume be interesting to our readers.

The Fredriksstad Elektrokemiske Fabriker A. S. expects to be operating by the middle of 1914 and will manufacture metallic sodium, sodium peroxide, and other sodium compounds such as sodium cyanide, also possibly potassium chlorate.

The sodium works at Vadheim in Sogne has largely increased its output during 1913, having now a producing capacity of possibly four hundred to five hundred tons of sodium per year.

The electric zinc furnaces at Sarpsborg (similar to those at Trollhättan, Sweden) are said to be running profitably. Other proposed electric zinc smelting processes do not seem to have yet reached that stage. Mr. Tharaldsen of Trondhjem is reported to have developed a new electric zinc smelting process at the Ilen Smelteverk. Mr. Raeder of Kristiania is also developing an electric zinc furnace, being backed by a German firm in Nerpelt, Belgium.

The Skienfjord Kraft A. S. has rented 10 to 15,000 horse-power to a German firm, for the manufacturing of silicon and calcium carbide. Prime Minister Gunnar Knudsen is the president of this power company, which is developing several water falls near Skien. Every week there are reports of new companies utilizing large and small water falls in all parts of the country for the purposes of light and power.

In this connection it is interesting to note that, at the same time, modern gas works are being erected in the smaller towns of Norway, mostly for heating and industrial purposes with utilization of the by-products.

The great water-falls of Bjlvefos in Hardanger, and Matre and Tyin in the Sogn district are now being developed. The Government is taking up the regulation of the river Nummedalslaagen by constructing dams and forming lakes in the highlands.

The "Societe Norwegienne de Nitrure" has acquired the Serpek patents for producing aluminium nitride in Norway, with a capital of ten million francs. A plant is being erected at Arendal.

The "Norsk A. S. for Elektrokemisk Industri" has increased its capital from 4 to 6 million kroners. It is not known exactly to what purpose this new capital will be put. This company has started many important electrochemical enterprises in Norway.

The Hardanger Electric Iron and Steel works, at Tyssaa near Odda stopped operations last year. This was one of the enterprises of the Norsk A. S. for Elektrokemisk Industri. This company has formed a mining company "Grong gruber" to work the large pyrites deposits north of Trondhjem. The Dunderland Iron Mining Company is reported as rehabilitated with English capital, to work the low-grade pure magnetite deposits, formerly worked by the Edison methods. They will be worked by a new electromagnetic concentrating and briquetting method, which is expected to give much more valuable and better results.

The old state silver mines at Kongsburg, which have been worked for nearly three hundred years, have in recent years increased their production, until it is now over twenty-two thousand pounds of silver per year. Other rich silver mines have been recently found in the same neighborhood and may soon be operated.

Plans are on foot to start large cement works near Drammen, using the rich limestone from the marble quarries at Lier; the capital is stated as two million kroners.

The "Alby United Carbide Factories" has obtained important concessions from the Government for the development of the Aura Falls near Molde. Mr. Blackstad is directing the company's activities in Norway.

Altogether, 1913 has been a very prosperous year for Norway, especially for the important steamer and sailing ships of the mercantile marine; crops have also been abundant, and there is plenty of money among the people. The importance of new railway connections to open up the country in all directions is being more and more realized. A new railway is projected to connect Kristiania and Trondhjem, having a branch to Molde and Aalesund. Another railway is projected north of Trondhjem to run to Narvik, with a possibility of running farther north. West of Kristiania a railway is being constructed from Kongsberg to Notodden and Telemarken, which will ultimately continue to Christianssand and Stavanger. A railway is also planned between Odda and Haugesund, near Stavanger. The railway between Kristiania and Drammen will probably be electrified in the near future; the railway being built between Myrdal and Fretheim in the Sogn will also be electric.

The Marconi wireless telegraph stations erected at several places on the coast have been of important aid to shipping during the year. In December, two 7000-ton Swedish steamers, the "Norrbotten" and "Italia," were saved by the Marconi station on the Lofoten Islands giving them instructions by wireless and telegraphing for pilots to conduct them to safety. A new station will be opened next summer near Stavanger, at the cost of 2 million kroners, which is expected to communicate directly with Newfoundland and New York.

Another great national enterprise, a connecting link between the Norwegians in America and the remaining half in Norway, is the "Norske Amerika Linje" which commenced in 1913 with two modern twin-screw steamers, the "Kristianiafjord" and the "Bergensfjord," running directly between Kristiania-Bergen and New York. The greater part of the capital of this company is held by Norwegian citizens in the U. S. A. As Norway will celebrate in 1914 the centennial of its present constitution, a great influx of visitors is expected from the United States, and the National exhibition at Kristiania will be opened May 17th of this year. It is expected that all the visitors from America will come by the new Norwegian steamships.

We have spoken at some length of the ocean steamship lines, since they play an important part in the industrial development of Norway, by opening new foreign markets for its products, and supplying new sources of raw materials. Other direct steamship lines from Kristiania to the Gulf of Mexico, Fredriksstad to South Africa, Australia and India have also had a prosperous year, and provide very cheap rates for Norwegian exports.

One Norwegian industry has not participated in the general prosperity, viz., the wood-pulp and paper industry. This industry is suffering from too great capacity of production, and raw material has advanced greatly in price. Large steamers arrive at Fredriksstad and Sarpsborg from Finland and Russia loaded with wood for the wood-pulp factories on the River Glommen. An English-Norwegian enterprise was the sending of a steamer of 1600 tons around the north of Norway and of Russia far into the River Jenissej in Siberia, under the guidance of Prof. F. Nansen, returning with a cargo of the much-needed wood. This water way promises much for the Siberian lumber trade and exports, as well as for Siberian importations from Europe because of cheap freights. Prof. Nansen was very cordially received by the Russian and Siberian authorities and a company has been formed to exploit this new trading route.

The Teckniske Hiskole of Trondhjem will turn out its first class of graduates in the summer of 1914. This Institute can at present accommodate 100 students in each year of a 4 years' course. It is projected to double the capacity, so that Norwegian engineers can get their higher technical education at home, instead of going abroad, as they do, mostly to Germany.

The idea of holding in 1916 a joint meeting in Norway, of the Bunsen Gesellschaft of Germany, the Faraday Society of England, the Société de Chimie Physique of France, and the American Electrochemical Society will meet with great enthusiasm in Norway, where the electrochemical industries have recently combined in a union for the protection of their common interests. The Editor of "Teknisk ukeblad," the foremost Norwegian technical paper in Norway, is forwarding the project enthusiastically.

# High-Temperature Resistivity of Refractories; a New Method of Measuring, with Results for Alundum

BY EDWIN F. NORTHRUP

In connection with the commercial application of electrothermics, even more than for its scientific interest, it is important to have a method for rapidly and precisely measuring the electrical resistivity of refractory materials at the high temperatures at which they are used. With such a method available not only trained investigators but students seeking subjects for these might employ their time to good advantage in obtaining a series of values for all the common refractories which are in use in electric-furnace practice.

While the writer has other problems which are absorbing his attention and is unable to find time to make a series of determinations of the resistivity of refractories, he was compelled to devise and test out a method, as supplementary to his other work, for measuring to a temperature of at least 1600 deg. C. the electrical resistivity of alundum cement. The test of the method proved that it is so easily applied and gives such concordant results that it seems wise to describe it here in the expectation that it will meet with favor and be put into practise by others and that we shall not have to wait long to have tables of constants and sets of curves of the electrical resistivities of the commercially useful materials which stand high temperatures.

That these measurements have not been made before is probably due to the fact that without special devices the difficulties in the way of making the measurements are insuperable. As the value of the data rapidly increases with attainment of higher temperatures it is necessary to be provided with a furnace which will meet the following conditions:

A temperature of over 1600 deg. C. must be obtainable.

The temperature must be uniform over a considerable length of the furnace chamber in order that all parts of the refractory being measured will be submitted to the same temperature at the same time, and this temperature must be under perfect control. The furnace chamber must be filled with an atmosphere of carbon monoxide, because, as will be subsequently shown, graphite makes the most suitable electrodes between which to clamp the refractory material being measured and graphite will burn up in an oxidizing atmosphere.

Alternating current must be used for the measurement. If a refractory material be clamped between two electrodes and then be submitted to a high temperature it will be found that when a feeble direct current is passed through it, it develops back electromotive forces as if it were a kind of storage battery. Electric conduction at high temperatures, in these cases, is probably a mixture of electronic and electrolytic conduction. The problem in making the measurement is, therefore, not different than the problem of measuring the internal resistance of a battery.

If the material being measured is clamped between two flat surfaces of conducting material, as graphite, a little consideration will show that there is no material available which can be used to press the two surfaces upon the refractory so as to give good contact without forming a shunt upon the resistance being measured. This difficulty, which for a time appeared to the writer unsurmountable, has been absolutely overcome as will later appear.

The measuring current must be conveyed to and from the material under measurement with something which conducts well when the temperature is over 1600 deg. C.

Up to 1600 deg. C. the temperature may be measured with a platinum vs. platinum + 10 per cent rhodium thermocouple. A casing for the couple of Royal Berlin porcelain will stand this temperature provided the porcelain tube is not in contact with anything. As it is quite viscous at 1600 deg. C., it will be deformed by anything it touches and the glaze will cause it to adhere tenaciously.

In the measurement described this means was adopted for measuring the temperature and the temperature was not carried higher because of the limitation of the couple. The writer has under development a far superior method for measuring a temperature with very great precision which will be described in a later report. It is not an optical or radiation method.

All the requirements for accurately measuring the resistivity of refractories are met by the method which is now to be described.

The refractory material to be measured is first molded in three thin rectangular slabs. The size of these slabs, which was adopted in the measurement here described, was width 3.4 cm, length 4.8 cm and thickness 0.25 cm. As the details for treating the refractory material to be measured would differ somewhat according to the nature of the material being measured, the description here given will apply specifically to the material which was measured in testing out the method. This material was a very finely ground alundum cement made by the Norton Company, Worcester, Mass., and designated by them as grade RA 355. To mold these slabs it is necessary to add to the cement a very small quantity of water and then press the material into a metal mold under considerable pressure. When dried out in a gas oven the slabs are sufficiently coherent to handle without breaking.

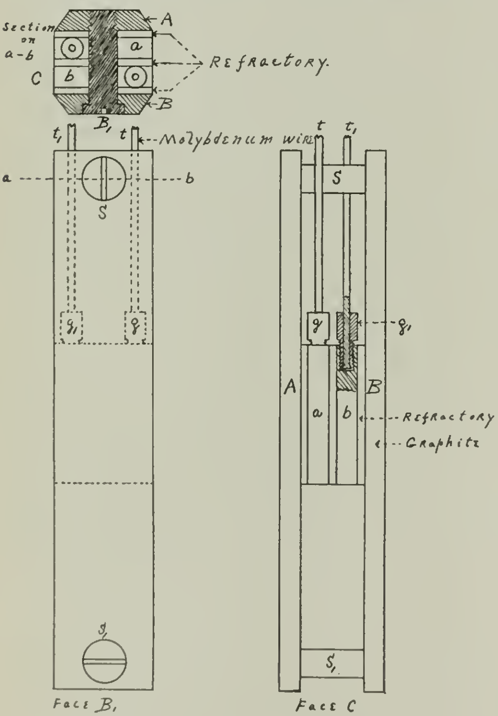


FIG. 1—ARRANGEMENT OF TEST

These three slabs are now clamped between graphite plates in the exact manner shown in the drawing, Fig. 1. In the drawing, *a* and *b* are two graphite plates of the same width and length as the slabs of refractory but about 0.8 cm thick. *A* and *B* are two other slabs of graphite of the same width as *a* and *b* but considerably longer. As actually used in the experiment the A and B slabs were made 9 cm long, but the writer's experience shows that they should have been made at least 25 cm long for a very important reason; the graphite screws S and $S_1$ serve to clamp tightly together the three refractory and the four graphite slabs, as Fig. 1 plainly shows. As there is more or less expansion or contraction of the refractory material when submitted to great temperature changes, it is necessary in order that uniform pressure be at all times maintained on the refractory pieces, that the slabs A and B be long enough so that the natural spring of the graphite may act to maintain the pressure on the refractory pieces.

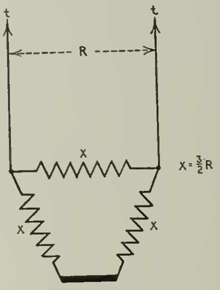


FIG. 2—ELECTRICAL CONNECTIONS

Electrical connection is made in the manner indicated in Fig. 1 to the graphite slabs, *a* and *b*. The two wires which serve as terminals are made of molybdenum approximately 2 mm in diameter. This wire melts above any temperature obtainable in the furnace and as there is a CO atmosphere in the chamber the wire does not oxidize. The wires are fastened to the slabs *a* and *b* with graphite screws $g$ $g_1$ in the manner shown in Fig. 1. It will be noted that we now have an electrical circuit between terminals $t$ and $t_1$ which is like that diagrammatically shown in Fig. 2.

If we call R the measured resistance between terminals $t$ and $t_1$ and $x$ the unknown resistance of each one of the similar slabs of refractory, we have

$$R=\frac{x.2x}{3x} \quad \text{or}$$

$$x=\frac{3}{2}R \quad \text{.............................} (1)$$

If $l$ is the thickness of one slab and S is its cross-section, namely its width by its length, and $\rho$ its specific resistance in ohms per cm³, we have

$$x=\frac{l}{s}\rho \quad \text{.............................} (2)$$

From Eqs. (1) and (2)

$$\rho=\frac{3s}{2l}R \quad \text{.............................} (3)$$

With the dimensions chosen for each of the slabs of refractory 3s/2l equaled, within the limits of accuracy of the measurement, just 100. Hence

$$\rho_t=100\ R_t \quad \text{.............................} (4)$$

The subscript $_t$ means that $\rho$ and R are determined at the measured temperature t° C.

The arrangement shown in Fig. 1 was placed in the bottom of the tubular chamber of the furnace. (This furnace was described by the writer in Metallurgical and Chemical Engineering, January, 1914.) The two molybdenum terminal wires passed up through a cylindrical cover piece of baked lavite which tightly closed the top of the furnace. The thermocouple tube passed through this cover piece and the end of the thermocouple was brought close to the refractory pieces being measured. The two projecting molybdenum terminals were joined to the X posts of the bridge arrangement to be described, and the thermocouple e. m. f.'s were read with a potentiometer. The cold junction of the thermocouple was maintained at 0° C. by being located in ice water in a Dewar flask.

Experiences with this and previous measurements had taught the writer that the chemical composition of all refractory materials is not in an equilibrium position when raised to a high temperature which is higher than that at which it has previously been raised. It therefore, becomes necessary before starting to make measurements to pre-heat the material to a temperature as high or higher than that which one intends to reach in the measurement. Before beginning the measurement, for obtaining final values, the material was heated twice to over 1500° C.

As was expected, it was found impossible to make measurements having any accuracy using direct current. As soon as attachments were made to the X post of a bridge a galvanometer of 1 megohm sensibility would fly off the scale. The writer does not like to make measurements with alternating current using a telephone as a detector, because a telephone does not tell whether the balancing resistance is too high or too low. He prefers an electrodynamometer method. This method has been described by the writer in his book on "Methods of Measuring Electrical Resistance," paragraphs 1113 and 1120. The method enables one to measure the internal resistance of a battery or any device which includes an electromotive force in its circuit with quite as much ease and certainty as one would measure a metallic resistance. The electro-dynamometer suitable for the purpose is the one described by the writer in paragraph 1001 in the above-mentioned book. This was the instrument used in obtaining the resistivity of alundum cement and the method as applied will be readily understood from the diagram, Fig. 3. 110-volt alternating current was used. The condenser C in the diagram was 1 micro-farad and the current which passed through this condenser was quite sufficient for adequate sensibility.

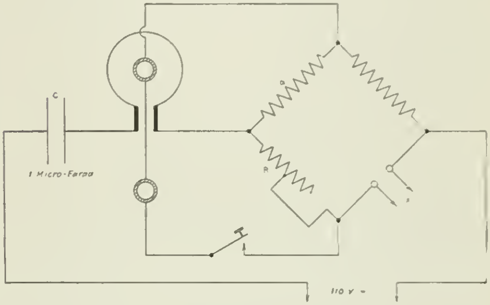


FIG. 3—METHOD OF MEASURING ELECTRICAL RESISTANCE

The measurements of temperature and resistance were taken with rising temperature in the furnace. This is preferable to taking measurements with falling temperature because with rising temperature everything is expanding and the refractory pieces are maintained more tightly clamped between the graphite slabs.

The curve, Fig. 4, shows the results obtained.

———It was suspected that the inflection in the curve which occurs at a temperature of 1100° C. was an error. Therefore, the clamping pieces were removed, refractories examined and everything re-assembled and the measurement was repeated. The inflection occurred the second time at almost precisely the same point and it is concluded that it is a real phenomenon connected with the material. Whether it exists or not, however, has small bearing upon the engineering aspects of the properties of alundum.

The greatest chance for error in these measurements arises from the difference in the resistance which may arise from varying pressure of the graphite slabs upon

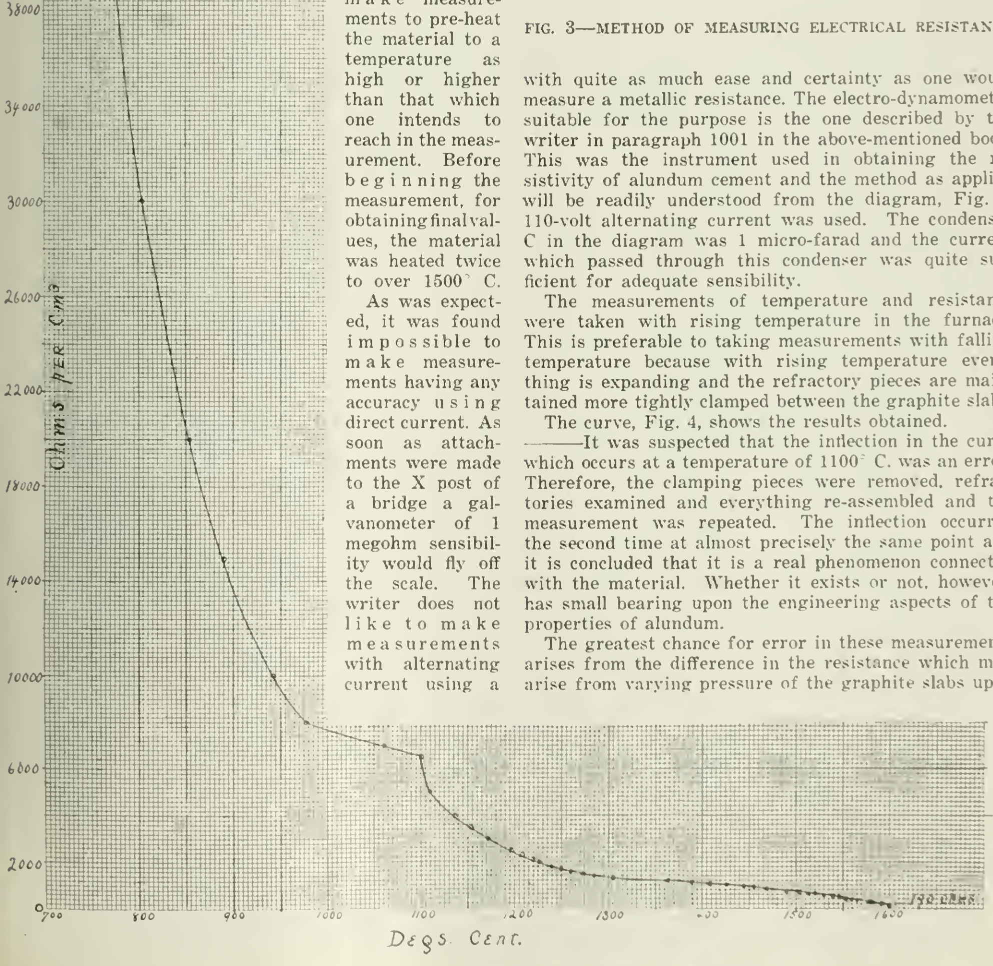


FIG. 4—RESISTIVITY OF ALUNDUM AS FUNCTION OF TEMPERATURE

the refractory pieces. To assign a probable precision to the points on the curve would require more repetitions of the measurement than the writer's time will permit him to undertake. Relative values can be very closely relied upon, say within 2 or 3 per cent, and absolute values, the writer thinks, can be trusted within 10 or 15 per cent. After all, it is only the order of magnitude and the manner of variations of the resistivity of refractories which is required, because the composition of all such materials is far too variable to call for the determination of constants to any high order of precision.

Palmer Physical Laboratory,
Princeton, N. J.

## Dry Chloridization of Ores

BY JOHN L. MALM

It has been my intention to offer for publication no statement on the treatment of complex ores by dry chloridization until it would be possible for me to report the results of successful commercial operation of the process or state the cause of its failure. The excuse for offering it at this time is to supplement a discussion of the subject appearing in this journal, and to supply such general details as have been a matter of special inquiry.

Details of apparatus design or manipulation generally govern success or failure of a process, and therefore are of the greatest importance in the description of any operation. It is, however, impossible to offer complete details of any scheme which has not been in operation on a commercially profitable scale; and even were such the case, details would differ in the treatment of various ores. Such details as are offered here have been determined by large-scale tests under conditions which probably would govern successful commercial operation.

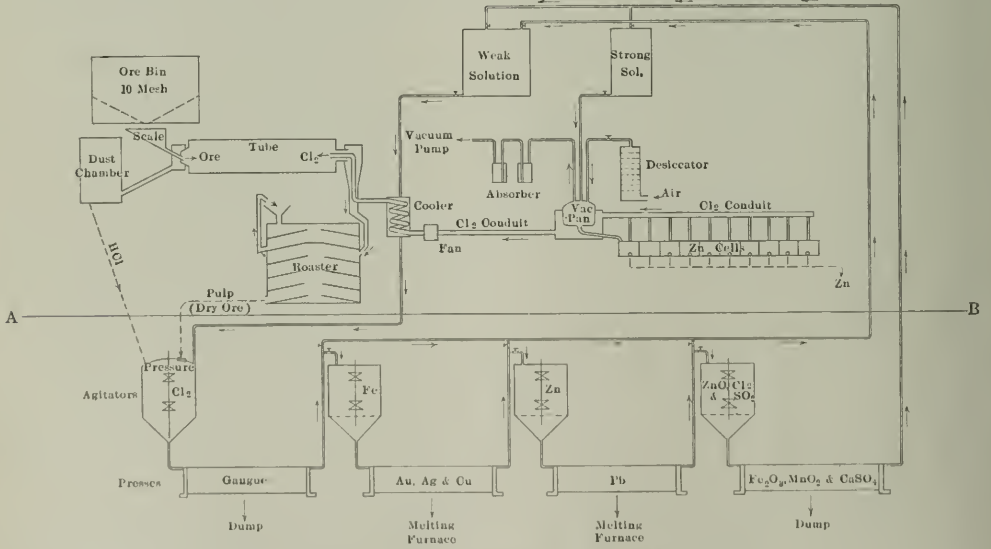


FIG. 1—DIAGRAM SHOWING APPLICATION OF DRY CHLORINATION

With reference to the accompanying diagram of operations, Fig. 1, it is to be noted that the operations indicated above the line *A-B* are to be regarded as standard under my proposed method, while those below the line are suggested only as a probable procedure in handling solutions of the metals indicated.

In the following outline I have found it convenient to reiterate some statements already made in a paper by Mr. A. G. Brownlee, read before the American Mining Congress at Chicago, October, 1911, and in Mr. Harry J. Wolf's description in the May, 1910, issue of the *Western Chemist & Metallurgist.*

### Chloridizing in Tube Mill and Roasting Furnace

The method of dry chloridization is applicable to the treatment of a great variety of sulphide ores, and is independent of the physical condition of the sulphides in the ore. It starts with the ore as it comes from the mine and gives metals as final products, thus combining the functions of a concentration mill, smelter and refinery. Concentrated or separated minerals offer no advantage except in a reduction of transportation charges.

The ore is crushed to about 10-mesh, properly dried and fed to a revolving tube mill, where it is subjected to the action of chlorine gas. The ore is fed continuously at one end of the tube and discharged at the other. The chlorine gas is introduced at the end of the tube from which the ore is discharged. The ore is kept in contact with the gas long enough to chloridize from 40 per cent to 70 per cent of the metal contents. In the treatment of ore containing more than 10 per cent sulphur combined with iron or manganese, sufficient chloridization should be effected in the tube mill to form the necessary iron chloride which, on later decomposition in the roasting furnace, will furnish the necessary chlorine to cause the chloridization of the metals sought.

It is evident that the sulphides may be chloridized in two ways, viz., by free chlorine gas directly and by chlorine carried by sulphur monochloride. It is probable that both actions take place in the tube, but just where one action stops and the other begins is subject to question. After the action in the tube is under way there is no evidence to show that chloridization is not entirely effected by the chlorine of the sulphur chloride, and that the chlorine gas admitted to the tube is not first combined with sulphur, the latter acting as a carrier to deliver the chlorine to the metals of the sulphides and then make its exit with the gangue. This proposition leads to the theory that there are zones of chloridization in the tube, the positions of which are subject to shifting brought about by the adjustment of supplies of ore and chlorine.

By a proper regulation of the ore and gas supplies, and the addition of air, the temperature due to chemical reaction can be controlled. After this partial chloridization in the tube mill, the ore is conveyed to a roasting furnace, preferably of the multiple-hearth type. Here the partially chloridized ore is subjected to the action of heat, furnished by the burning sulphur or supplied from an external source. The heat decomposes the iron and similar chlorides and liberates chlorine, either free or as hydrochloric acid, leaving the metals of the decomposed salts in an inert oxide condition. The chlorine or hydrochloric acid liberated unites with the sulphides or oxides of silver, copper, lead and zinc, forming chlorides of these metals.

In order to produce the desired action, the chloridizing agents should be in excess, and means are provided, therefore, for the collection of chlorine gas escaping from the main chloridizing hearths of the furnace. One way of effectively conserving the excess chlorine is to pass the furnace gases containing this element through a bed of sulphide ore. In the use of a six-hearth furnace as shown in the diagram, the ore from the tube mill is fed into hearth No. 3 and progresses downward. Hearths Nos. 1 and 2 are supplied with raw sulphide ore which circulates through these hearths. The gases enter these two upper hearths from the lower or main chloridizing hearths, and filtering through the sulphide ore pass to the stack. A portion of the ore from the two upper hearths is by-passed to hearth No. 3, the quantity depending on the rate of absorption of chlorine by the raw sulphide ore.

### Solution of the Chloridized Metals

The ore thus treated in the furnace is passed to an agitator to which water or mill solution is added. The heated ore and the heat evolved by the process of solution is sufficient to make possible the solution of such chlorides as lead and silver. Chlorine may be added at this point if found necessary to bring the gold into solution. From the agitator, in which all the metals go into solution as chlorides, the pulp is treated in properly designed filters where the gangue, ordinarily consisting of silica, sulphur and the oxides of iron and manganese, is retained.

The combination of a mechanical agitator and blowcase has proved most effective in accomplishing solution of the chlorides. This apparatus is constructed of impregnated wood like a large barrel. When solution is complete, steam is admitted which forces the pulp through the filter; and by forcing steam through the residue after the solution had been removed, a highly efficient wash is obtained with a minimum of water. The filtering medium is asbestos cloth. The filter residue may be sluiced over amalgamated plates to recover any gold or silver not dissolved.

### Concentration of Solution and Precipitation of Metals

The further treatment of the solution depends on its metallic content, particularly zinc, and on the burden of the sparingly soluble salts, *e.g.*, $PbCl_2$ and AgCl. The solution is circulated between the weak-solution storage tank and the agitator until its metal contents justify refining, after which it is treated according to the following general scheme. It is first agitated in the presence of metallic copper which precipitates gold and silver. The solution is decanted and agitated with metallic iron to precipitate copper. Lead is then removed by precipitation with metallic zinc; and, if necessary, the solution is treated with zinc oxide, carbonate or silicate, chlorine and sulphur dioxide, to remove iron, manganese or lime. These latter impurities may have existed in the solution on account of insufficient decomposition in the roasting furnace, or may have been introduced in the substitution process described above for the removal of metals. The zinc precipitant for this latter purpose may be either the natural minerals or zinc oxide obtained by the roasting of zinc ores.

### Electrolysis of Fused Zinc Chloride

After the above treatment the solution contains only zinc chloride. It is passed to the vacuum evaporators where the moisture is removed, and then fed to electrolytic cells in a fused condition. Metallic zinc is deposited and chlorine liberated for reuse. The cells are operated at a temperature of about 450 deg. C., and the gas escapes at approximately the same temperature. It may be passed under the vacuum pans to aid in evaporation and at the same time be cooled to a temperature suitable for use in the tube mill.

The various precipitates of gold, silver, copper and lead are collected separately in filter presses, dried, melted and cast into bars.

### Chemical Data

Practically all the work done on this process hitherto has been directed to obtaining results, and not particularly to chemical interpretation of all the reactions involved. Although conditions apparently are favorable to the formation of sulphates, particularly that of lead in the roaster and agitator, the fact remains that their occurrence has not been observed in any tests. For example, a recent test on an ore containing 6 per cent lead and 3 per cent sulphur yielded an extraction of over 99 per cent lead. This test was run under conditions apparently favorable to the formation of lead sulphate, and yet this did not appear.

The following statements are based upon actual experience with the process. While the metal precipitants in contact with solution are always in excess, the substitution reactions are practically quantitative, as the solution during the refining stage is neutral. Any acidity caused or acquired is utilized in the agitator treatment of the ore from the roaster. The necessary hydrochloric acid is obtained from the decomposition of $S_2Cl_2$ in the dust chamber.

The successive precipitations occur rapidly, and all the precipitants are granular and easily filtered. Owing to the high solubility of most of the chlorides formed, the solutions can be maintained in concentrated condition.

The degree to which ferric chloride is permitted to form and enter solution is determined by the quantity of ore containing oxides, carbonates and silicates which are available for treatment.

The metallic precipitates are freed from any associated metal used as precipitant by washing the precipitate with a solution of its chloride.

The larger the scale on which this process has been applied, the easier has it been to maintain control of the operations; and its application to commercial practice has been anticipated only in the light of "continuous and concurrent operations, where ordinary human beings are a function."

The electrolysis of fused zinc chloride has proved a much more simple operation than the electrolysis of sodium chloride solution. The chlorine loss has been found so low as to be almost negligible as a cost factor. The high efficiency of the zinc chloride cells has established commercial zinc chloride as the source of chlorine for starting operations and for replacing such less as may occur. The ore itself has proved the most satisfactory storage for chlorine.

# Notes on Chemistry and Metallurgy in Great Britain

(*From our Special Correspondent*)

### Cement Testing

Mr. W. L. Gadd recently read a paper before the Concrete Institute which deserves the attention of all who are interested in the testing of cement. His main object was to call attention to the fallacies existing in certain recognized processes of testing, not excepting some of those found in the British Engineering Standards Specification.

First, with regard to time of setting, the author said that the object of exposing the sample spread out to a depth of 3 in. for 24 hours seemed to be partly to cool the cement to a normal temperature, and partly to get it under the conditions similar to those resulting from keeping the cement in sacks or casks for a few weeks. The cooling manifestly could be effected without exposing the cement to the air; and the results of storage were very various.

He made experiments with two large samples of cement, one recently ground and the other ground a month previously, which were put into sacks and taken to warehouses at six different works. Six samples were the produce of rotary kilns and six of chamber kilns. After fourteen days the sacks of cement composing each sample were well mixed, sampled and put aside for a further fourteen days, when another mixture and taking of samples was carried out.

The tests showed that in most cases the time of initial setting was quicker after both fourteen and twenty-eight days; but there were two exceptions, one of which first showed and afterward quickened, and the other quickened and afterward became slow. This went to show that cement kept in sacks in a dry condition might become either slow or quick in time of setting.

He found that the results obtained from samples aerated for twenty-four hours, as laid down by the Engineering Standards Specification, did not agree with those of the bulk sample from which they were taken, and it was demonstrated that the time of setting was affected by the conditions of storage, and although the samples tested varied considerably in composition, they all exhibited erratic behavior in this respect.

Direct experiments with pure dry air showed that this did not affect the setting time; but moist air free from carbon dioxide had a marked effect, while absorption of carbon dioxide was proved to considerably accelerate the setting time.

With regard to sieves for determining the degree of fineness, he had examined many rolls of wire cloth strictly agreeing with standard specification, but yet totally inaccurate for their intended purpose. The real standard should be the size or area of the holes in the sieve; and the diameter of the wire threads and their number per inch were of secondary importance.

The size of the sieve itself also affected the result. A very fine sample he found to leave 3.5 per cent on a large sieve, and 5.6 per cent on a smaller one—a difference of 37 per cent.

The determination of the specific gravity was still laid down in the Standards Specification, but it was not really any indication of a proper degree of calcination, and it depended to a great extent upon the age of the cement, and whether it had absorbed carbon dioxide and water. These were Butler's conclusions, and he entirely agreed with them.

Then, again, certain specifications directed that the specific gravity should be taken after drying the cement at 100 deg. C.; but this was quite useless, because carbon dioxide would not be expelled below 300 deg. C.; and he was of opinion that the only reliable guide in the case of doubtful cements was chemical analysis.

Standard sand was generally supposed to give the best results obtainable with any given sample of cement in respect to tensile and crushing tests; but this view was not correct although the standard sand ensured comparable results. Then, again, different countries used different standard sands, and it had been proved that the crushing resistance of concrete made with the same cement varied with the size as well as with the nature of the aggregate.

The autoclave test was only a revival of Dr. Erdmeyer's high-pressure steam test, which German cement experts had rejected as unreliable and misleading; and the results of American and Canadian research showed no ground for its adoption.

On the question of free lime the author remarked that the view that unsoundness of cement was due to free lime had been strongly held for a long time and was now widely accepted; but the theory that the expansion of cement was due to the presence of free lime was not supported by any authenticated facts. His opinion was that unsoundness was most probably caused by an abnormal silicate, very possibly dicalcium silicate, an unstable compound which disintegrated slowly with resulting increase in volume.

### The Institution of Petroleum Technologists

Last month the guarantors of a fund for the foundation of an Institution of Petroleum Technologists held a meeting for the purpose of establishing this new institution. The desirability of forming such a society has been very apparent during recent years not only for the technologists but for the benefit of all who are engaged in the petroleum industry. The main objects of the institution are the collection and dissemination of reliable information in all branches of petroleum technology; to afford facilities for interchange of ideas on methods of production, refining, transport, storage and uses of petroleum and shale oil and their products; and to insure the attainment of a high standard of efficiency by technologists.

On the proposition of Professor Vivian B. Lewes, seconded by Mr. A. C. Adams, Sir Boverton Redwood was unanimously requested to accept the office of president. After accepting office, Sir Boverton announced that more than seventy applications for membership of the institution had been received.

### Market Prices, December, 1913

| *Higher* | £ s. d. | *Lower* | £ s. d. |
|---|---|---|---|
| Zinc, ton | 2. 6 | Copper sulphate | 1.10. 0 |
| Iron, Cleveland | 5 | Shellac, cwt. | 4. 0 |
| Scotch pig | 7 | Tin ore | 12. 0. 0 |
| | | Tin standard | 8. 0. 0 |

| | £ s. d. |
|---|---|
| Aluminum | 85. 0. 0 |
| Alum, lump loose, per ton | 5.10. 0 |
| Antimony, Star Rejulus, ton | 28.10. 0 |
| Borax, British refined crystal, cwt | 18. 6 |
| Copper sulphate, ton | 22.10. 0 |
| Caustic soda, 70%, ton | 10. 8. 0 |
| Copper ore, 10 to 25%, unit | 11/3 to 11. 9 |
| Ebonite rod, lb | 4. 6 |
| Hydrochloric acid, cwt | 5. 0 |
| India rubber, Para, fine, lb | 3. 1¼ |
| Mica, in original cases, medium | 3/6 to 6. 0 |
| Petroleum, Russian spot, gal | 9¼ |
| Quicksilver (Spanish) per bottle | 7.10. 0 |
| Sal ammoniac, cwt | 2. 2. 0 |
| Sulphate of ammonia, ton | 13. 0. 0 |
| Sulphur, recovered, ton | 5.10. 0 |
| Shellac, cwt | 4. 8. 0 |
| Platinum, oz., nominal | 9. 5. 0 |
| Tin, ore, 70% per ton | £100- 2. 0. 0 |
| Zinc, Vielle, Montagne, ton | 25.12. 6 |

---

**Colorado plants** of the A. S. & R. Co. smelted 683,082 tons of ore in 1913, producing 293,836 oz. gold, 13,194,944 oz. silver, 136,247,052 pounds of lead, and 7,119,089 pounds copper. The gross value of the production was $20,996,305.

# Presentation of the Perkin Medal to John W. Hyatt

## Interesting Notes on the Early History of Celluloid, Continuous Water Filtration and Other Inventions of Mr. Hyatt

The eighth impression of the Perkin gold medal for important work in industrial chemistry was presented on January 23 to Mr. John Wesley Hyatt, the inventor of celluloid, continuous water filtration, his roller bearing system, etc., at a joint meeting of the New York Sections of the Society of Chemical Industry, the American Chemical Society, and the American Electrochemical Society.

Mr. Gustave W. Thompson, chairman of the New York section of the Society of Chemical Industry, presided. The meeting was well attended and the occasion most enjoyable.

The chairman, Mr. Thompson, discussed in his introductory speech scientific imagination as the chief faculty required in men up to the mark to become Perkin medalists. The beloved dean of American chemistry, Professor Charles F. Chandler, followed with a record of Mr. Hyatt's life work and formally presented to him the Perkin medal. Mr. Hyatt, sprightly in spite of his seventy-six years, expressed his sincere thanks and gave a most interesting account of the invention of celluloid and a description of his sugar-cane mill. The proceedings were concluded by Dr. Frank Vanderpoel, who gave some delightful personal reminiscenses from his association of many years with Mr. Hyatt.

JOHN WESLEY HYATT

### Chairman's Address

The opening address was made by the chairman, Gustave W. Thompson. After some brief remarks on the origin of the Perkin medal, he continued:

"The medal is awarded for valuable work in applied chemistry. Whatever the future may have as interpreting the grounds for merit, in the past it has generally been considered that this work should be in the nature of original or inventive work which has proved of great public value. The question I would propound to you to-night is: What is the mental faculty which has made the recipients of the Perkin medal what they are? In what respect do these men differ from their fellow chemists, which has enabled them to be so successful in the application of chemistry to the arts? * * *

"In 1870, Tyndall delivered his famous discourse on the 'Scientific Use of the Imagination.' In this discourse he showed the value of the imagination properly made use of in solving some of the most difficult problems of physics. Tyndall has shown us how the imaginative mind, seeing resemblances in things, can supply the missing parts in such resemblances, those missing parts being hidden from the senses.

"It was this power of the imagination which enabled Kekule to lay the basis for the working out of the structure of many complex organic compounds, which work has been of incalculable benefit to chemical science and industry, and thousands of instances could be given showing that practically all of the progress made in the science of chemistry has been due to this proper use of the imagination; but considering the work done in applied chemistry, we see clearly that it was the imagination of Herreshoff that enabled him to develop the metallurgy of copper, and of Behr in his work on the separation of the oil contained in the germs of corn, and of Acheson, who saw in his imagination that, if flocculating agents existed, there were probably also *de*-flocculating agents, and of Hall, who believed that somewhere there was a solvent for alumina, from which aluminium could be obtained electrolytically, and of Frasch, who saw in the oil and salt wells the suggestion of the possibility of recovering sulphur from the bowels of the earth, and of Gayley, who saw the possibility of the dry blast in increasing the output and decreasing the cost of the blast furnace—and tonight, in the case of Hyatt, who saw in the drop of dried collodion the possibility of producing a plastic mass, which was finally obtained in celluloid.

"It was Tyndall who emphasized the extreme value of the two little words 'as if' when used by the scientific mind, showing how, from things seen, a scientific imagination can lay bare things unseen and make possible discoveries of great value. Discoveries often come by accident, but it is the imaginative mind that sees in these discoveries future possibilities. It is the imaginative mind which, following out discoveries so made, is led into unlimited fields of usefulness. We must not think, however, of imagination as being the sole factor, although it is probably the principal factor, in the production of valuable works. There must be energy, concentration and persistence, which will carry such a mind across the Jordan into the promised land. Nevertheless, the imagination is the most important factor here, because, without it, there would be no promised land.

"As we look around about us upon those with whom we are intimate, we see this imaginative faculty in all degrees of development, and I have this work of suggestion to offer: Those of us here who are educators, in whose hands are being moulded the minds of future chemists, should we not ask them whether the work which they are doing tends to develop this imaginative faculty, or whether it is indeed possible for them to sow in the minds of their students the seeds of imagination if they do not already exist there?

"It seems to me that there is no better place, no better occasion, than this place and this occasion, when we are honoring, by the presentation of the Perkin medal, a man in whom the imaginative faculty was highly developed, to put before you the need of the imaginative faculty in as emphatic a manner as possible and to urge that in our educational institutions this faculty should be developed to the highest degree, for, if we are honoring Mr. Hyatt on account of his possession of this faculty, should we not seek to increase the number of those who possess the faculty in a high degree? Is not the real purpose of the Perkin medal something more than the honoring of its recipients—great as that purpose is—is it not for the purpose of encouraging those faculties on which the presentation of this medal rests?"

### Presentation Speech by Dr. Chandler

Professor Chandler in his official presentation speech first gave a brief account of Mr. Hyatt's early life.

"Mr. Hyatt was born at Starkey, Yates County, New York, in November, 1837. He was aducated in the public school and later in the Eddytown Seminary, where he excelled in mathematics.

"In his early boyhood he acquired a strong taste for mechanical affairs in his father's blacksmith shop. In his sixteenth year he went to Illinois and learned the printing business, working at this trade for the following ten years. . . .

"He then went to Albany and worked as a journeyman printer for about two years. Seeing a $10,000 offer for a substitute for ivory for billiard balls by Phelan & Collander, of New York, he began experimenting nights and Sundays in the hope of gaining the reward. He made a number of useful plastic compositions, none of them, however, good enough for billiard balls, but he started to make checkers and dominos of pressed wood, and with his two brothers established what is now the Embossing Company, of Albany, N. Y., which has been a highly successful concern for more than 40 years, under the mechanical management of Mr. Hyatt's younger brother, C. M. Hyatt.

"In 1870 he invented and patented a machine for turning billiard balls, by which an unskilled workman can do as much as a dozen skilled workmen could accomplish by former methods, securing at the same time perfect accuracy.

#### THE INVENTION OF CELLULOID

"His attention having been called to the character of the solid nitrocellulose left by the evaporation of liquid collodion or artificial skin, as it was called when collodion was first put upon the market for covering cuts and other wounds, he turned his attention to the subject of nitrocellulose as a suitable material for producing plastics. It should be remembered that gun cotton, or nitrocellulose, was first discovered by Schoenbein in 1845. In 1847 Maynard announced the discovery that while nitrocellulose is not soluble either in alcohol or ether alone, it is soluble in a mixture of the two, and he gave the name collodion to the solution, which has since found its way very extensively into medical use. It also served to solve the problem of producing photographic pictures, either positives or negatives, upon glass, practically sounding a death knell for the beautiful though troublesome daguerreotype process. The wet collodion process was introduced by Scott Archer in 1851.

"Hyatt was entirely ignorant of the various efforts which had been made by Parks, Spill and others to utilize soluble nitrocellulose or pyroxyline for the manufacture of plastic materials, and consequently he started out without any hints or suggestions as to how he should proceed. His first success resulted in the manufacture of billiard balls by first making a solid core of another plastic material and covering the same with nitrocellulose dissolved usually in ether and alcohol. The process was so successful that a good business was established in 1870.

"In the meantime Hyatt invented celluloid and began the manufacture of celluloid and bone dust billiard and pool balls. At this time his brother, Isaiah S. Hyatt, joined him, and they worked together until the brother died in March, 1885.

"I do not propose to give a detailed history of the progress made by Mr. Hyatt and his brother in establishing the celluloid industry. I will merely remark that Hyatt's patent 88,633, dated April 6, 1869, was for a molding composition to imitate ivory and other substances composed of fibrous material and gum shellac or other solid fusible adhesive gum.

"His patent No. 88,634, dated April 6, 1869, was for an improved method of coating billiard balls, consisting in dipping the billiard balls made of some suitable composition into a solution of collodion which might be given any desired color beforehand.

"His patent 89,582, dated May 4, 1869, was for a composition consisting of ivory dust or its equivalent mixed with collodion and subjected to pressure during the evaporation of the solvent.

"His patent 91,341, dated June 15, 1869, taken out by the two brothers jointly, was for manufacturing solid collodion with very small quantities of the solvent dissolving the pyroxyline under heavy pressure, thus securing great economy of solvents and a saving of time.

"Their patent 105,338, dated July 12, 1870, shows the fundamental invention of celluloid. It is entitled Improvement in Treating and Molding Pyroxyline. The three claims of the original patent are:

"1. Grinding pyroxyline into a pulp, as and for the purpose described.

"2. The use of finely comminuted camphor-gum mixed with pyroxyline pulp, and rendered a solvent thereof by the application of heat, substantially as described.

"3. In conjunction with such use of camphor-gum, the employment of pressure, and continuing the same until the mold and contents are cooled, substantially as described.

"This patent was reissued three times in order to avoid ambiguities. The claims of the last reissue are as follows:

"1. The use of finely comminuted camphor-gum mixed with pyroxyline pulp, and rendered a solvent thereof by the application of heat, substantially as described.

"2. In conjunction with such use of camphor-gum, the employment of pressure, and continuing the same until the mold and contents are cooled, substantially as described.

"The specification fixes the proportion of about 1 part of camphor to 2 parts of pyroxyline. Modifications of this process were embodied later in U. S. patents 156,352 and 156,353.

"From this time on celluloid became a most important plastic, superior in almost every respect to any other plastic hitherto proposed, for the manufacture of the greatest variety of articles useful and ornamental.

"Seventy-five different patents were taken out either by John Wesley Hyatt alone or in association with his brother, Isaiah S. Hyatt, and an enormous establishment grew up at Newark in the hands of the Celluloid Company."

Professor Chandler then mentioned that in one of the most important and recent works on applied chemistry he found the statement that celluloid "was first produced by Daniel Spill, of Hackney, England, and came into commerce under the name of xylonite. Spill's method of converting the nitrocellulose has been followed for more than forty years."

Professor Chandler emphasized that there was no logical ground for making that statement. Celluloid was invented by the brothers Hyatt and not by anyone else.

It is quite true that many other experimenters sought to prepare useful plastic compounds with the aid of pyroxyline prior to the Hyatt invention of celluloid. But no one succeeded in producing anything like celluloid. Professor Chandler proved his point by a careful and detailed analysis of the patents of Alexander Parks and Daniell Spill, and showed that Spill, in his British patent 1739 of May 11, 1875 (nearly five years after Hyatt's collodion patent) made no reference to any material that could possibly be called celluloid. This whole matter has been threshed out in the Federal courts as long ago as 1886, and the Hyatt patents have been sustained, although everything that had been patented or published was carefully studied and discussed during the litigation.

### OTHER INVENTIONS

"Mr. Hyatt's activities were not limited to celluloid. Among his other inventions also of great importance we find a *sugar cane mill*, very superior to any mill previously used in its efficiency, both in increasing the percentage of juice extracted from the cane and greatly diminishing the time necessary to extract it, and giving a higher value to the refuse bagasse as fuel.

"In the early 80's Mr. Hyatt and his brother Isaiah took up the subject of *water filtration* and started a company called the Hyatt Pure Water Company. Isaiah Hyatt invented and patented a very important feature of the filtration process February 19, 1884, Patent 293,740. It marks the beginning of a new era in water purification. Coagulants had been previously used to purify water, but the difficulty was that the water was held in large tanks or cisterns. The coagulant was added to it, the whole was thoroughly agitated and then it was necessary to allow it to stand 12 to 24 hours for the coagulum to settle to the bottom. The Hyatts conceived the idea of employing a coagulant which could be added to the water while it is on the way to the filter, so that no large settling tanks or basins are required and no time is lost. The claim of this patent is as follows:

"The method herein described of arresting and removing the impurities from water during an uninterrupted passage of the same from a supply pipe into a filtering apparatus, thence through a filter bed contained therein and out through a delivery pipe leading therefrom, which method consists in introducing into the water simultaneously with its passage to or into the filter a substance which will sufficiently coagulate or separate the impurities to facilitate their arrest and removal by the filter bed, thus obviating the necessity of employing settling basins.

"I was connected with a litigation which followed the issue of this patent, and studied the process and apparatus at Somerville, N. J., Niagara Falls and Elmira. The process was unusually successful. At Somerville the river water exhibited a milky opalescence caused by such fine particles of clay that no filter would clarify it. By a proper attachment of an alum box to the feed pipe to the filter, a minute quantity of alum was added to the stream of water on its way to the filter, less than one grain to the gallon and in the few seconds that elapsed before the water reached the filter bed of the ingeniously constructed Hyatt filter, coagulation had taken place and the coagulum, including the alumina of the alum and the clay, bacteria and other suspended impurities of the water, had been converted into such flocks as made it possible for the bed of sand in the filter to arrest it completely. These Hyatt filters are so constructed, whether they are on a large scale or small scale, that they can be washed completely at any convenient moment by simply reversing the current through the filter. This churns up the sand and separates from it the accumulated coagulum.

"Nearly all the paper mills and woolen mills in the country were and still are supplied with these filters, as are also more than 100 cities and towns.

"The validity of the patent was established through law suits which were brought against the city of Elmira and the city of Niagara Falls. In 1891-2 Mr. Hyatt took up the subject of *antifriction roller bearings* with great success.

"I think that the facts to which I have called your attention, although very briefly expressed, will satisfy you of the great achievements of Mr. Hyatt and will fully justify your committee in placing Mr. Hyatt beside Sir William Henry Perkin and the six American chemists who have already received the Perkin medal.

"It gives me great pleasure, as the representative of the Society of Chemical Industry, and the affiliated chemical and electrochemical societies, to place in your hands, Mr. Hyatt, this beautiful token of the appreciation and affection of your fellow chemists."

## Mr. Hyatt's Speech of Acceptance

Mr. Hyatt spoke as follows:

"I have never looked forward to any such honors as you have bestowed upon me, and I do not know how fittingly to express my gratitude. You have overlooked my lack of early training in the sciences with which you are all familiar, and only look to results which have been obtained mainly by persistent and, many times mistaken, experiments. Some successful experiments I might never have made if I had been familiar with the danger theories of some learned men.

### THE INVENTION OF CELLULOID

"From my earliest experiments in nitrocellulose, incited by accidentally finding a dried bit of collodion the size and thickness of my thumb nail, and by my very earnest efforts to find a substitute for ivory billiard balls, it was apparent that a semi-liquid solution of nitrocellulose, three-fourths of the bulk of which was a volatile liquid while the final solid was less than one-fourth the mass of the original mixture, was far from being adapted to the manufacture of solid articles, and that I must initially produce a solid solution by mechanical means.

"The only useful solvent known to me at that time was a mixture of alcohol and sulphuric ether; with the old formula (about equal parts of ether and alcohol) I mixed in a closed mill a thick paste of soluble cotton, made by the old firm of Charles Cooper & Co. After mixing, the cover of the mill was removed and the mass evaporated down to a thick dough, which was then forced accurately around the ball (made of another substance), and allowed to dry.

"This I found resulted in a rather brittle coating, owing, as I found, to the unequal evaporation, leaving only the alcohol, a poor solvent by itself, at the final shrinkage. This was remedied by using only the least amount of alcohol (five parts ether to one alcohol) necessary as a solvent. Even this coating shrunk to less than half of its original thickness and required to be dried immersed in water under several hundred pounds' pressure per square inch to insure its solidity and freedom from bubbles. It became necessary to strain the mass by forcing it through a very fine sieve to exclude the unnitrated fibers.

"All these difficulties stood in the way of success, except in high-priced articles like billiard balls. Other seriously objectionable features became apparent. In order to secure strength and beauty only coloring pigments were added, and in the least quantity; consequently a lighted cigar applied would at once result in a serious flame, and occasionally the violent contact of the balls would produce a mild explosion like a percussion guncap. We had a letter from a billiard saloon proprietor in Colorado, mentioning this fact and saying he did not care so much about it, but that instantly every man in the room pulled a gun.

"I next had a small beating engine made, to pulp the nitrocellulose. In one experiment I placed a small quantity of this dried pulp in a strong cylinder and forced quickly a minimum quantity of liquid solvent into it with high pressure. The result was a solid substance, as hard as sole-leather, which soon dried, leaving a fine hard disc about three-fourths of an inch in diameter and one-half an inch thick. While no explosion ever resulted from this, there was real danger to be feared, and the matter was dropped.

"My brother, I. S. Hyatt, joined with me at that time, and finding it stated in some patents to which I was referred, that a little camphor added to the liquid solvent was beneficial, we conceived the idea that it might be possible to mechanically mix solvents with the pulp and coloring matter while wet, then absorbing the moisture by blotting papers under pressure, and finally submitting the mass to heat and pressure.

"To our surprise, we noticed a slightly solvent action of the precipitated and washed camphor upon the pulp, even before the heat and pressure, and without other solvent we succeeded in producing a transparent slab one-fourth of an inch thick, fine, and as hard as wood.

"My brother took some samples to the American Hard Rubber Company, with the view of interesting them. They employed the late Professor Charles A. Seeley, who had made collodion for the government during the Civil War, to investigate the matter. He came to our place in Albany, N. Y., and we conducted the whole process for his inspection, very successfully. He remarked that he had come prepared to detect some chicanery, but could see no deception, and expressed himself as satisfied. He kindly advised us that if, accidentally or otherwise, we were to apply a little too high temperature, the quantity we were dealing with would inevitably destroy us with the building and adjacent property. While we did not accept this as true, it was disturbing.

"The following day between 12 and 1, when all were out, I rigged up a four-inch plank used as a vise-bench, braced it between the floor and ceiling, between the hydraulic press and the hand pump, intending it to shield me from possible harm. I then prepared the mould, heating it to about 500 degrees Fahrenheit, knowing it would certainly ignite the nitrocellulose and camphor, and would abide by the result. The gases hissed sharply out through the joints of the mold, filling the room with the pungent smoke. The mold, press, building and contents were there, including myself, very glad that I did not know as much as the professor.

"The next step was to make a small stuffing machine, consisting of a cylinder, four-inch bore, about a foot long, terminating in a tube three-fourths of an inch bore, ten inches long, immersed in an open oil-jacket, with a gasburner and thermometer. A capnut with one and one-fourth inch screw forced a plunger upon the cakes of incipient celluloid, which were heated at the outlet end of the cylinder passing through the heated tube into molds, and also through nozzles forming rods, tubes, etc.

"We found it advisable to lower the melting point of the camphor by adding a small quantity of alcohol or other solvent of camphor. A much larger hydraulic stuffing machine was then made. Dental plate blanks were the principal part of our early business.

"My brother interested some New York capitalists —principally composed of General Marshall Lefferts, Joseph Larocque and Tracey R. Edson—and we removed to Newark, N. J., in the winter of 1872-73. We had nearly all the appliances and machinery to design and build, which progressed with some halts and mistakes for two or three years, when a fire occurred in our four-story and basement building, utterly destroying all our stock and machinery, and pushing out the whole front of the building (which was very weak), and severely injuring several of our men, who all finally recovered, although one—Mr. Charles S. Lockwood—was in great danger for a long time. We then started our present works, acquiring knowledge and experience, my brother starting a separate factory for making brushes, mirrors and combs. Early in 1878 my brother went to Paris and started the French Celluloid Company.

"Before we left Albany we began the use of tissue paper in place of carded cotton or bleached flax, which finally resulted in getting tissue paper of definite thickness and materials, and breaking it up into small separate pieces by a machine I constructed, drying these separate pieces in a loose mass and nitrating them instead of the carded cotton.

"In 1876 I was allowed to employ a chemist for determining our acids and to systematize our nitration, instead of merely using hydrometers and thermometers, and Mr. Frank Vanderpoel was selected by me. So far as I know, the analyses of mixed spent acids was not reduced to practical work. Professor Seely proposed that we separate the nitric and sulphuric acids by distillation, and then bring these to the proper strength before mixing, which was not adopted. Vanderpoel first removed the gelatinous flock by adding finely powdered natural barium sulphate and allowing the barium and flock to subside, which was a great success. I had previously tried filtration, which was impractical.

"After much labor Vanderpoel perfected a quick and accurate method of determination of the spent acids, and then added the required fresh acids. An elaborate and extensive battery of tanks was constructed, the acids being moved through copper pipes, where required, by means of air pressure. The tanks for mixing the comminuted tissue paper with the prepared acids were arranged on a turntable supporting a dozen or more tanks, each holding hundreds of pounds. A rotating stirrer was arranged to stir in the requisite amount of paper in one tank, the turntable being revolved to the next tank, and so on. At a distance embracing about half a dozen tanks from the stirrer was located a centrifugal machine, which separated out most of the acids. The nitrated paper was then thrown into a washing device, and the partly washed paper then fell into large tanks of fresh water and was thoroughly washed. A very considerable number of tons of paper per day were and are treated in this way.

"The next procedure was to grind this nitrated paper in a beating engine. The water was then mainly removed by a centrifugal machine. The mixture of pigments camphor and nitrocellulose was then made, according to the results required, and ground together in a mill, then pressed into slabs or cakes, and still further deprived of moisture by great pressure, and finally deprived entirely of moisture by blotting papers repeatedly changed. These cakes are then broken up and alcohol or other desired solvents added and allowed to soak in. The partly dissolved mass is then masticated in heated rolls, turned out into necessarily rough sheets, is cut into strips and rolled up into cylinders, ready for the stuffing machine.

"The great want was to furnish celluloid in solid perfect sheets, and this neither the rolls nor the stuffing machines could possibly do, with all our experience. I constructed a special nozzle for the stuffing machine, to form a slab about one and one-half inches thick, seven inches wide and several feet long, which was pressed between steam plates, one of them with undercut grooves, to hold the slab. A machine was made with shaving knife and reciprocating bed, and by it the slab was shaved into sheets of the desired thickness. These slabs were necessarily imperfect, and were too small. After showing this result to the other directors, I proposed building a hydraulic pressure steam-heated mold, to make a slab or block about two feet by five, and three inches thick, in which to weld and press a pile of rough sheets from the masticating rolls.

"General Lefferts, our much-beloved president, had suddenly died a year or more before. To those who knew the least about celluloid my suggestion looked pretty good, but to others came a great fear of possible danger and failure to weld up such a mass. At last they gave me authority to build the apparatus, limiting me to less than half its cost if fairly estimated. With this authority, which consisted more of the privilege of trying such an apparatus than in providing for its cost, I ordered the machine, agreeing to pay the machinist all above the appropriation if it failed to work.

"The machine was built and most carefully tried in the presence of only the new president, who knew little about celluloid, and Mr. Stevens and Mr. Lockwood among the employees. The mold was cooled and opened, and nice sheets were at once made, considering that only scrap material was used, though less than half the block was welded. This meant reheating, which was at once done, and the whole was known to be a success.

"I dwell upon this because of its vast importance to us. It multiplied the value of celluloid many times, making a much stronger and finer material than was produced by the former means.

"About this time we were enjoined from bleaching the iron out of the pulp, caused by the iron-beating knives, and it was up to me to remedy the serious difficulty. A large revolving drum of copper, through the axis of which was a shaft with beating arms rotating at a very high speed, in which the mixture of nitrated paper, camphor and pigments was placed, and the whole beaten to a pulp without the discoloration of the iron and water, and without the loss in washing and bleaching the fine pulp from the beating engine.

"In order to clearly differentiate my work in celluloid from that of others in the nitrocellulose industry, I will summarize as briefly as I can:

"First, the idea of combining with the nitrocellulose only the exact or approximate amount of solvent required for a solid solution. This required a nearly perfect mechanical mixture before very much solvent action could take place.

"Second, completing the solution by means of heat and pressure.

"Third, eliminating the practically unnitrated fibers by pulping.

"Fourth, employing tissue paper in place of carded fiber.

"Fifth, avoiding the terrible danger of drying out the moisture by exposure in drying room.

"Many years ago I patented the process of first pressing out all the water possible and displacing the remainder by forcing alcohol through under pressure. This, I understand, is now used by other nitrocellulose workers, but we prefer the method herein described.

"Sixth, the stuffing machine process.

"Seventh, the sheeting process, most essential.

"Mr. Stevens has been with me ever since he was fourteen years old, and has invented solvents and many other things of great importance in the art, and stands at the head of nitrocellulose workers at the present time.

"Mr. Harrison, in his department, has invented the method of imitating the grain of ivory, of smoked pearl, of onyx, and of many other beautiful colors and effects. He has been with us nearly forty years. Others are entitled to much credit, but it is impossible to name them here."

Mr. Hyatt then gave a description of his sugar-cane mill, an account of which is reserved for a later issue. Mr. Hyatt concluded as follows:[*]

"I have taken out 238 patents (a few of them being joint inventions with others), and several new industries have resulted. The one of next importance to celluloid is named The Hyatt Roller Bearing Co. I have received considerable liquid money, most of it having been of a volatile and inflammable nature. Age ought to bring wisdom."

### Dr. Vanderpoel's Reminiscences

Dr. Frank Vanderpoel began his remarks with a personal tribute of affection to Dr. Chandler and Mr. Hyatt. He became Mr. Hyatt's chemist three years after he had left Columbia University.

"To refer to the early days of the celluloid business in Newark, there seemed to be a good deal of prejudice against it in that city. On account of an unfortunate fire which took place there shortly after the company began operations, the people of Newark did not, as a rule, take kindly to a material which was reported as being made of gun-cotton and camphor. Of course, a statement like this would never lose in transmission, and the public would look askance at any article of commerce which contained as an ingredient this high explosive. I remember a story told of a man who happened to touch, with a lighted match, one of a pair of cuffs made of celluloid when, to his amazement there was a terrible explosion, and he barely escaped with his life—or words to that effect.

"Well, this and other stories of a like nature produced a strong feeling against the manufacture of this new substance, to say nothing of its use by the public and, of course, some one had to bear the brunt of it. Naturally, the inventors (the Hyatt brothers) and those most intimately associated with them in business, had to carry the burden; and it wasn't a very light one either. But our friend had the enthusiasm of the inventor, an enthusiasm which he imparted to those who were associated with him, and without which success would have been long delayed, if not impossible.

"I suppose that, in the minds of some, even at the present day, the idea exists that the principal ingredient in the material referred to is true gun-cotton, the highly nitrated compound of cellulose. This is because the public, as a rule, is not given to distinguishing between the compositions of different chemical compounds. If, in order to make true gun-cotton, you treat cotton fibre with a bath composed of a mixture of strong sulphuric and nitric acids, why, it stands to reason—so some of these people think—that cotton fibre treated with a bath of these same acids, no matter what their percentage composition may be, will be converted into the explosive compound. You know that this is not the case, but the general public does not, or did not, some thirty years ago.

"Shortly after I became associated with the celluloid company, samples were made of these two varieties in nitro-cellulose, using raw cotton fibre in each case, and their solubility tested in a strong solvent, and thus compared. Any nitro-cellulose which would not dissolve in this solvent would be utterly worthless as a basis for the manufacture of our product.

---

[*] Mr. Hyatt told informally a little story which, while not included in his official address, is too characteristic to omit it from this report. An employee of his of many years—a foreigner who had never learned to talk correct United States, in spite of his other abilities—came to die. Said he: "Me now die. John Hyatt die some day too. Perhaps me go hell. Me don't care. John Hyatt build ice machine"

"Upon making the test, the fibres of the lower nitrated compound disappeared in the solution upon the instant that they touched the solvent. This was the variety of the nitro-cellulose which was the principal ingredient in the manufacture of celluloid. How long do you suppose it took the other, the true gun-cotton or tri-nitro-cellulose (or, as some call it, hexa-nitro-cellulose) to dissolve? It was kept in the bottle of solvent for more than six years without showing the slightest evidence of a solvent action—each fibre standing up bravely—then it was thrown away. But the public didn't know of this difference and thought that the product of our friend's brain was a menace to every one who came near it. Prejudice will go a great way, and it takes courage and pluck to fight it.

"Mr. Hyatt's share in the work of making celluloid did not consist in merely getting out the various patents and handing them over to the company. He was often at the works, superintending, advising, assisting in the manufacture, and always on call if things needed his attention. We all felt confidence in his judgment and found afterwards that this confidence was not misplaced.

"The inventor's enthusiasm is a valuable asset or adjunct in the matter of bolstering up the faint-hearted employee who may sometimes think that he has an idea of his own which he would like to have exploited. I think that more than one of the men employed at the works received encouragement from our friend, Mr. Hyatt, in certain lines of work in which they were engaged and which they might have been inclined to give up if it had not been for his enthusiasm and optimism. It not infrequently happens, in this world, that the success which a naturally timid person achieves is due, in some degree, to the encouragement which he may receive from one who has more courage and backbone. As the boys would say, "He doesn't get cold feet," and this means the difference between success and failure. We sometimes need optimistic friends who will help us over the rough places, or the thin ice—put it whichever way you will. Mr. Hyatt was one of these.

"This comforting way of looking at things does not mean, let me say, that everything that a fellow would think of, and suggest, would be endorsed by him. I well remember a remark made by him one day when he had occasion to relate how a certain so-called or self-styled chemist had utterly failed in the solution of a problem which he was absolutely certain he could solve. In fact, he claimed to have solved it some time before, but when a second attempt was made, the result was not in the least satisfactory. "Yes," said Mr. Hyatt, "A man may say to you, 'if I put this brick which I have here on this side of the street with that one over across the way, I'll have two bricks'; but when he goes across the street he finds what he saw on the other side was not a brick, after all!"

"Very likely Mr. Hyatt does not remember this occurrence, but I assure you it is true as is also another one which happened at the works and illustrated his practical way of looking at things.

"You know it is just as important, sometimes to know what to omit doing as to know what to do; what to leave out of your invention as well as what to put into it. A mutual acquaintance, an employee of one of the branches of the celluloid company, went to our friend one day and told him of an invention which he had almost worked out in his mind, and asked his opinion of its value. He was going to make billiard balls out of celluloid, these balls to have a hollow center, and this small cavity was to be partly filled with mercury which, when the ball was struck, would act as a sort of break on the motion of the ball, and cause it to slow down. Mr. Hyatt's reply was, 'Well, if billiard balls came ready-made and partly filled with mercury as you suggest, and you could find some way of getting that mercury out, I think it would be a fine thing.'

"There was one element in our friend's makeup concerning which I cannot speak too highly, for the reason that you don't find it anywhere. In fact, I believe it to be the exception and not the rule. It was his willingness to give every one credit for his own idea and not attempt to appropriate it himself. Sometimes he went further than this; he would take the thought that you gave him, enlarge upon it, or improve it, and then hand it back to you as your own. How many do that today? I think that if you counted them on your fingers, you'd have some fingers left over when you had gotten through counting. . . . There is another quality or characteristic possessed by the successful inventor which is a most important asset. Something which happened not very long ago on a train running across the Arizona desert may, in a slight degree, illustrate the point. The day was hot and dusty, and anybody who has ever traveled those alkali deserts with nothing much in the way of vegetation but sage brush in sight, can tell you what that means. It is decidedly uncomfortable, to say the least, and you look in vain for a cool spot where your eyes may rest—a clump of trees, or a little running water.

"One of the passengers kept looking out of the window every minute or two, pulling the shade to one side as he did so, and then letting it drop back again into place. Another passenger, noticing the interested look on his face asked him what he saw. 'I see miles and miles of corn, acres of wheat and cotton and the whole country covered with farms,' he said. 'When the supply of water back of the tops of those mountains is tapped and brought down here to this prairie, we shall have it blossoming as the rose.' What is your name, the other passenger asked. 'Luther Burbank,' was the reply.

"Now what shall we call this quality or element in the composition of the successful inventor and advanced thinker along these lines? Some might say, 'efficiency.' Well, that is a good name for it. It means making two, three or twenty corn stalks grow where none, or at the most, only one grew before. It means causing the dry desert to become a veritable garden. It means taking a product of the laboratory which before had been only a chemical curiosity, and working upon it in such a fashion, and with such determination that it shall become a most useful article of commerce which shall find application in a multitude of ways and bring comfort, yes, and happiness to many a home."

---

**Gold in Canal Zone streams** has been investigated by the official geologist for the Isthmian Canal Commission, who reports that in no instance has the metal been found in quantities that would justify its recovery. Many samples were washed, yielding from a color or two up to 2½ cents per cubic yard.

**Dressing Copper Plates.**—A correspondent of the *South African Mining Journal* states that he has found a simple remedy for discoloration and greasy scum on amalgamating plates. In the dressing process he has discarded brushes and adopted chamois leather or Hessian sacking. In his opinion the brushes merely mix the scum with the amalgam, while the leather or sacking actually removes it. Since the adoption of this process the plates in the correspondent's mill are in excellent shape.

# Synopsis of Recent Chemical and Metallurgical Literature

## Gold and Silver

**Volatilization of Metals as Chlorides.**—In our issues for April and May, 1913, pages 220 and 230 respectively, mention was made of the process of treating sulphide ores with salt and volatilizing metal chlorides at a high temperature. This process was brought out originally by Pohle and Croasdale in the United States fifteen years ago, but was again discovered last year by Mr. Ben Howe, of Australia. In the issue of the *Mining Magazine* for December, 1913, Mr. Howe gives personally the results of his original investigations and the later tests which he made on a large scale at the Gwalia Consolidated mine in Western Australia. His work came to an unsuccessful end mainly, as he believes, because of unfavorable financial and local conditions; but it is interesting to note that he encountered the same difficulties that Pohle and Croasdale were unable to overcome years ago. In fact, Mr. Howe has stopped just where the earlier investigators left the process; and it is unfortunate that he could not have known of their work so that he could have conserved his funds and started with full knowledge of previous experience.

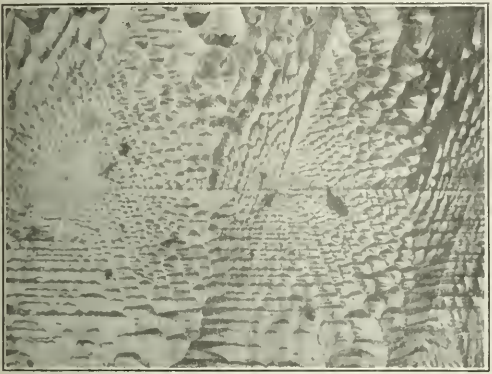


FIG. 1—PURE SILVER

The ore at the Gwalia Consolidated contains gold to the value of $9 or $10 per ton. Conditions of mining are favorable, but the metallurgy is difficult. The ore is a silicate of alumina, with quartz and calcite, containing sulphides of iron, arsenic and antimony. The mineral is finely disseminated through the gangue, and consequently mechanical concentration has proved a failure. Cyanidation after roasting yields only 75% recovery. Mr. Howe turned his attention to volatilization as a possible means of treatment, and met with some degree of success. In brief, the process consists in mixing the ore with salt, roasting at a temperature of about 1000 deg. C., volatilizing the gold as chloride, and recovering it in settling chambers and solutions as an amorphous powder.

Mr. Howe's difficulty centered in the absorption or condensation problem, and it is probable that he would have been impressed with this more quickly had he been trying to volatilize and condense chlorides of base metals such as copper. Having only gold in his ore, the problem was simpler. After allowing the fume to condense in chambers by reducing the velocity of the gases by expansion, and by providing baffles in the form of rods or wires such as are used in smelting works in this country, the gas was drawn through a series of absorption boxes by means of a vacuum pump giving a vacuum of from 1½ to 4 in. mercury. The vacuum boxes were arranged like zinc boxes in cyanide precipitation, and were filled with broken quartz for the purpose of breaking up the bubbles and exposing a large surface to the water. In a test run lasting 83 hr. Mr. Howe volatilized 92 per cent of the gold and recovered 85.7 per cent.

It was found that a long revolving furnace was best adapted to the work, and that the volatilizing process had been carried on most successfully when the discharged tailing appeared in the form of small fritted balls of gangue. Mr. Howe still has faith in the value of the process in treating certain refractory ores, and believes that the difficulties encountered can be overcome.

**Detection of Platinum Metals in Gold-Silver Cupellation Beads.**—It is well known that the presence of small amounts of the platinum group of metals in gold and silver beads obtained from cupellation causes a crystallization or frosting visible to the naked eye. It has been found, however, by Messrs. C. O. Bannister and G. Patchin that for beads containing less than 1.6 per cent of platinum it is necessary to use the microscope to detect the characteristic appearance of beads containing this metal. Their results, with many microphotographs, are published in *Bulletin No.* 111 of the Inst. of Min. & Met. Four of the microphotographs are reproduced herewith, being Figs. 1, 2, 3 and 4.

The summary of results and conclusions arrived at by the authors is as follows:

1. The microstructure of silver, gold and silver-gold cupellation beads is described and illustrated, and in the silver-gold beads the crystallization of silver and gold is distinctly traced in the structure. The visual appearance of beads composed of equal amounts of gold and silver is shown to be similar to that of beads containing over 1.6 per cent of platinum.

2. It is shown to be possible by simple microscopic examination to detect platinum in cupellation beads when present below 1.6 per cent.—that is to say, when present below the amount necessary to cause crystallization visible to the naked eye.

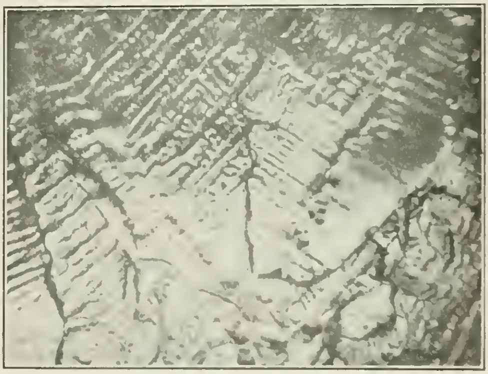


FIG. 2—SILVER (0.4% PLATINUM)

3. The presence of iridium in small quantities can be detected in silver beads by the strained appearance of the crystal caused by internal stresses.

4. The presence of traces of rhodium may be detected by a crystallization of the beads in which the facets of the crystals are distinctly visible. When over 0.03 per cent of rhodium is present this is indi-

cated by a bluish-gray color and a large amount of spitting.

5. Ruthenium is indicated in cupellation beads by a black crystalline deposit firmly attached to the bottom edge of the beads, and in the experiments carried out was always associated with a herringbone-like structure when examined by the microscope.

6. Palladium causes a structure similar to that found in the presence of platinum, but yields satisfactory evidence of its presence by coloration of the parting acid.

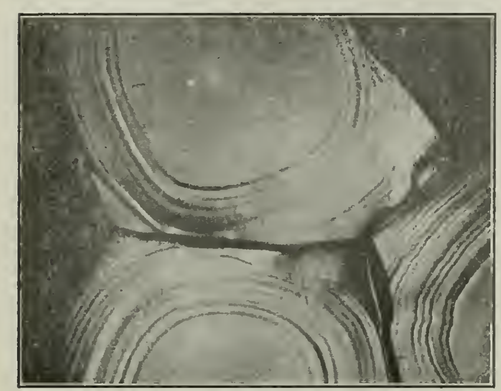


FIG. 3—PURE GOLD

7. No specific indications of the presence of osmium are afforded by the tests made.

8. The indications in the presence of iridium are found to apply equally well to osmiridium.

## Copper, Zinc and Tin

**Monolithic Magnetite Linings for Basic Copper Converters.**—Within the past few years the practice of converting copper matte in converters lined with magnesite brick has become almost universal and has practically displaced acid converting. The usual practice is to line a shell with magnesite brick varying from 9 to 30 in. in thickness in different parts of the shell, according to the severity of the chemical action. Sooner or later the lining spawls and cracks, owing to variations in temperature, and the lining must be renewed. The artificial production of a monolithic magnetite lining or coating over the magnesite brick is the subject of a patent granted to Messrs. A. E. Wheeler and M. W. Krecji, and of an article by them in the December *Bulletin* of the A. I. M. E.

This method of protecting a lining is based on the fact that magnetite is formed in artificial magmas, especially when the proportion of silica is low. Any excess iron over that required to combine with the silica is likely to be deposited in the form of magnetite. As the melting point of magnetite is probably not less than 1527 deg. C., and the temperature of the converter rarely goes over 1200 deg. C., it is evident that the lining of magnetite would have a higher melting point than the converter contents. The lining can be formed by blowing 35 per cent. matte for 10 or 15 minutes and then allowing the charge to cool by the addition of more matter. Alternate blowing and cooling, with the addition of more matte, is continued until the charge is blown to white metal. As no silica is added during this operation, magnetite is formed, and it can be observed as a coating over the magnesite lining. After this the converting operation, with added silica, can proceed as usual. The lining can be renewed at will by blowing matte without silica, and its thickness can be regulated by blowing with more or less silica. Under these conditions the lining should last a very long time, and should be of material value in protecting the magnesite bricks and in prolonging the life of the converter. Greater duty per lining obtained by this practice is ascribed by the authors to the protecting magnetite.

**Zinc Determination at Broken Hill.**—In our last issue, page 54, we gave a synopsis of the method for determining lead as adopted by a sub-committee of the Australasian Institute of Mining Engineers, and published in the *Proceedings* of that society, No. 10, 1913. The method for zinc adopted by the same committee is given herewith.

The committee considered only two methods, viz., titration of the zinc with potassium ferrocyanide, (1) in acid solution, and (2) in alkaline solution. Interfering elements in both processes are cadmium, copper, nickel, cobalt, manganese, iron and aluminium, and these must be separated before titration. Two modifications of the second method are given, consisting respectively in one and two precipitations of iron and manganese.

The titration in acid solution is well known in this country, and is considered standard. Opinions will be found to differ among our chemists as to the value of re-solution and precipitation of the iron and manganese. The Australian chemists, however, have adopted the titration in alkaline solution, with two treatments of the iron-manganese residue.

### *Solutions Required*

*Potassium Ferrocyanide.*—32.5 grams of the pure salt are dissolved in one litre of distilled water.

*Ferric Chloride and Potassium Tartrate Emulsion.*—200 grams cream of tartar and 2 cc. neutral ferric chloride solution containing 10 per cent iron are added to one litre of water. The emulsion must be well shaken before using.

*Outside Indicator.*—Pure glacial acetic acid, 99-100 per cent.

Pure metallic zinc or zinc oxide may be used for standardizing, but the latter should be ignited first to about 600 deg. C. and cooled in a dessicator. In the case of zinc weigh two lots of 0.25 gram and 0.1 gram, or of zinc oxide 0.3 and 0.1 gram, and dissolve in 5 cc. dilute $HNO_3$ (1.4). Evaporate gently until nearly dry and dilute with 100 cc. hot water. Add 7 grams $NH_4Cl$ and 8 cc. ammonia, make up to 300 cc. with hot 1 per cent $NH_4Cl$ solution, add 30 cc. tartrate emulsion, and titrate with ferrocyanide solution until

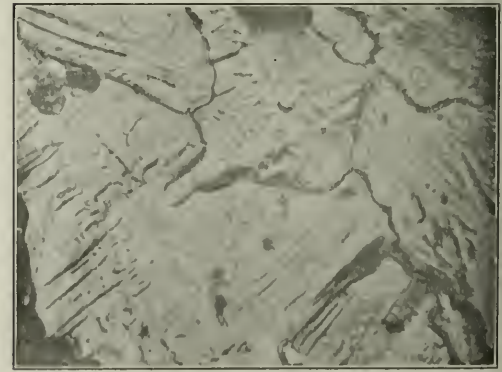


FIG. 4—GOLD (0.5% PLATINUM)

one drop added to a drop of glacial acetic acid gives a faint blue color. The standard and blank are calculated as explained for lead. (See January 1914 issue, p. 54.)

For sulphide ores weigh out 0.5, 1 or 2 grams, depending on the grade of the ore. No titration should require more than 25 cc. of the standard solution. Add 10 cc. $HNO_3$ and warm gently until decomposition is complete. Add 1 gram pulverized potassium chlorate and evaporate to dryness, avoiding overheating. For oxidized ores weigh similar quantities and treat first with 10 cc. HCl and evaporate nearly to dryness. Then add 10 cc. $HNO_3$, boil until all the HCl is decomposed, add the $KClO_3$ and proceed as above.

Treat the dry residue with 100 cc. water, 7 grams $NH_4Cl$, 15cc. $NH_4OH$, about ½ gram sodium peroxide, and boil for about 2 minutes. Allow to settle and then filter, washing two or three times with boiling 1 per cent solution $NH_4Cl$. Re-dissolve the precipitate in HCl, and reprecipitate the iron and manganese with 15 cc. $NH_4OH$ and 2 to 5 grams sodium peroxide. Boil for a few minutes, filter and wash as before. Heat the zinc solution to 70 deg. C., add 30 cc. tartrate emulsion titrate as directed above. If copper is present it is precipitated with granulated lead, the solution decantated and washed from the lead, treated with 30 cc. emulsion and 8 cc. $NH_4OH$ and titrated as before.

With very low grade ores the amount of ammonia may prevent precipitation of the zinc, and in such cases the solution must be treated with acetic acid until a precipitate begins to form, when the titration may be completed. The solution must not become acid.

The use of a small amount of sodium peroxide in the first precipitation is advantageous in two ways—it insures complete precipitation of the manganese and prevents bumping on boiling. The acetic acid used as indicator must be 99-100 per cent strong.

## Recent Chemical and Metallurgical Patents

### Iron and Steel

**Utilizing Blast-Furnace Flue-Dust.**—The incorporation of blast-furnace flue-dust in molten iron flowing from a furnace is suggested in a patent granted to Mr. Ralph Baggaley, of Pittsburgh, Pa. The process is similar to one patented by the same inventor in connection with copper smelting, in which it is proposed to incorporate flue-dust with molten matte before sending the latter to the converter. The inventor claims that his proposed method will be more simple than briquetting or bonding, and will obviate the difficulties encountered in those processes. He uses preferably a bath of molten iron as it comes from the furnace, and mingles with it the dry material to a point short of solidification. The mixture is then cast or taken in molten condition to Bessemer converters, open-hearth or electric furnaces where the refining stage is practiced. In carrying out the process, the heavy molten pig-iron is allowed to fall from four to six feet, or such a distance as will create a suitable vortex in the mixing vessel. The flue-dust is then discharged continuously at a point within the vortex and thus incorporated with the molten mass. It is not recommended that this process be used when the furnace is producing iron intended for remelting in a foundry, but rather when the furnace product is to be refined. (1,081,921, Dec. 16, 1913.)

**Nodulizing Fine Ore.**—In order to prevent the formation of rings of sintered material in nodulizing kilns, Mr. Lewis P. Ross, of Standish, N. Y., has patented a form of rotary kiln with cooling means so arranged that there are sections of low temperature in the walls of the kiln. This results in zones in which no adhesion occurs, between which the adhering material accumulates in separate sections. The latter ultimately fall of their own weight due to the lack of support. (1,081,063, Dec. 9, 1913.)

### Copper and Zinc

**Apparatus for Ammonia Process.**—In Fig. 1 is shown apparatus forming a part of an extraction plant for the recovery of zinc and copper from ores by means of ammonia. It is the invention of Mr. S. E. Bretherton, of Berkeley, Calif., who has been investigating the amenability of certain base ores to this process.

Two agitators A, A′ of like construction are arranged preferably close to each other as shown. From the apexes of the cone bottom pipes C, C′ are connected by branches D, D′ with the discharge pipe E of a pump F, the latter being driven by a motor G. The inlet pipe H of the pump F is connected by branch I with various tanks (not shown) for pumping solutions needed in the process. From the branch pipes D, D′ extend pipes J, J′ which enter the agitators and terminate at the lower end of the agitating tubes K, K′. The pipe H also has connections L, L′ extending into the settling tubes N, N′. Decanters O, O′ are connected by flexible tubes with pipes $O^4$ and $O^5$ which lead to pipe $O^6$ that is connected with a sump for receiving solution decanted from the agitators. Gages P, P′ are arranged on the sides of the agitators to show the height of pulp in each. The closed tops of the agitators are connected with each other by pipe Q for conducting gases back and forth during decantation and filling of the agitators. Means for discharging treated pulp from the agitators is provided in the pipes R, R′ leading to $R^4$. The discharged pulp may be conducted to filter press or leaching tanks for the extraction of contained gold and silver.

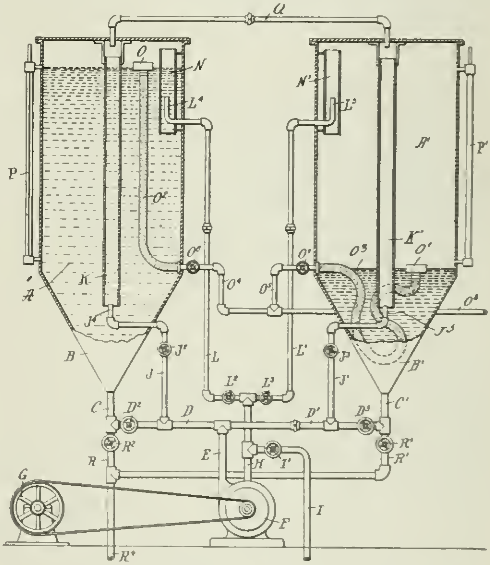


FIG. 1—AGITATORS FOR TREATMENT OF ORE BY AMMONIA PROCESS

The cycle of operations is as follows: 1. filling A (decanting wash A′); 2. agitating A (removing residue A′); 3. decanting A (filling A′); 4. rest (agitating A′); 5, filling wash A (decanting A′); 6. agitating wash A (rest); 7. decanting wash A (filling wash A′); 8, removing residue A (agitating wash A′). It is to be understood, of course, that the necessary valves are operated in connection with these operations. Agitation consists in circulating the contents of an agitator. The decanted solution is run to suitable precipitating apparatus. In the operation described it will be seen that decantation is effected without the admission of atmospheric air, since the gas contained in either agitator may flow into the other during decantation, and back again during filling with a new charge. Thus the dilution of the gas is prevented and impairment of the decanting process avoided. (1,082,797, Dec. 30, 1913.)

**Collecting Zinc Oxide Fume.**—As a substitute for canvas bags in the collection of zinc oxide, Mr. Morley P. Reynolds, of Cleveland, O., has patented a special form of apparatus with mechanical means for scraping the oxide from the collecting medium. The collector comprises two vertical cylindrical bags of wire cloth, supported concentrically, with an appreciable space between them. The wire fabric is strengthened and supported by T-bars attached exteriorly and running vertically. Suitable sheet metal covers close the tops of the bags. A vertical shaft extends centrally through the bags and is connected with a source of power at its upper end outside the bags, and journaled in a steadying bar below the bags. Attached to the shaft are arms carrying vertical wire brushes that may be caused to revolve against the inner surfaces of the bags and dislodge any material attached thereto. In operation the zinc oxide fume is introduced into the apparatus through a pipe at the bottom. Most of the oxide is caught on the inner bag, and such fume as passes the first bag is caught on the second. When sufficient fume has been collected, the wire brushes are put in motion to scrape the oxide from the bags and allow it to fall into a collecting receptacle which closes the bottom of the apparatus. The inventor claims that the device will be more effective than canvas bags, more convenient and less expensive. (1,082,766, Dec. 30, 1913.)

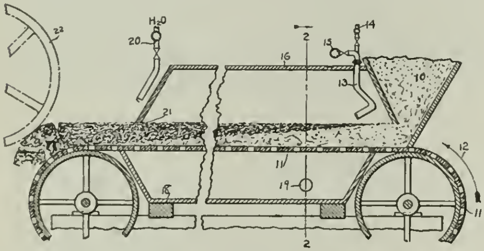


FIG. 2—HALL PROCESS FOR ELIMINATING SULPHUR FROM ORES

**The chloridizing roasting of ores**, such as copper, from which most of the sulphur content has been eliminated, has been carried out in various ways. Thus, after the ore has been heated to the proper temperature, salt has been added in the last stages of roasting and incorporated by rabbling. According to a patented improvement of Mr. Augustus D. Ledoux, of Summit, N. J., chloridizing can be carried on as a continuous process, dispensing with extraneous heat with the exception of such as may be needed to start chemical reaction between the ore and salt. Thereafter the process continues due to the heat generated by the chemical reaction. The operation can be carried on in a furnace of the MacDougal type. The applied heat of combustion starts chemical reaction which increases as the charge progresses through the furnace, and the process becomes continuous without further aid of heat from any extraneous source. (1,082,599, Dec. 30, 1913.)

**Hall Process of Desulphurizing Ores.**—The recovery of elemental sulphur from sulphide ores by roasting in a reducing atmosphere with admission of steam, is a process that is of interest to the copper smelter. In a patent recently issued to Mr. William A. Hall, of New York, N. Y., the inventor shows the application of his process in connection with a down-draft sintering furnace of the Dwight & Lloyd type. Fig. 2 shows such a furnace with an endless traveling grate on which an ore mixture is fed from a hopper. A combustion chamber 16 covers part of the grate surface where the reaction takes place. Immediately beneath the combustion chamber is another hood 18 provided with an outlet 19 leading to a suitable suction. Within the combustion chamber is a burner 13 adapted to use liquid or gaseous fuel. The flame is always maintained in a reducing condition. Steam is added through the pipe 15. A small stream of water may be applied to the ore as it leaves the combustion zone. The operation results in the elimination of sulphur in the elemental state, and its subsequent recovery in a suitable washer. At the same time the ore is sintered according to the process of Dwight & Lloyd. (1,083,252, Dec. 30, 1913.)

### Laboratory Apparatus

**Refractory porous articles**, such as filtering tubes, diaphragms, etc., in various shapes and for different purposes may be produced according to the specifications of a patent recently issued to Mr. Percy A. Boeck, of Worcester, Mass., and assigned by him to the Norton Company of the same place. Bauxite or other impure form of alumina, or purified alumina prepared by chemical methods, is fused in an electric furnace. This product is then crushed, forming what the inventor terms "alumina grain." The grain is then roasted to remove any trace of carbides or similar products, and mixed with a small proportion, 5 to 15 per cent, of plastic clay and sufficient water to form a thin slip. The desired article is then molded from this slip, dried at about 50 deg. C., and fired in a kiln at a temperature sufficiently high to vitrify or partly vitrify the bond. The resulting article is porous and retains in large degree the chemical inertness and refractory character of the alumina grain. (1,081,573, Dec. 16, 1913.)

**Glazed refractory articles** of the above nature, such as crucibles, combustion boats, insulators, etc., are made as described above, and then treated with a glaze compound which is the invention of Mr. Arthur T. Malm, of Worcester, Mass. Since the refractory alumina article described above has a high coefficient of expansion at temperatures below white heat, it is necessary to use a glaze of approximately the same coefficient of expansion. A porcelainic glaze of the following composition has been found satisfactory.

| | |
|---|---|
| Feldspar | 41.8% |
| Flint | 27.3 |
| Whiting ($CaCO_3$) | 17.7 |
| Clay | 13.2 |

A lead glaze compounded as follows also has proved suitable.

| | |
|---|---|
| Feldspar | 26.37 |
| Whiting ($CaCO_3$) | 14.38 |
| White Lead | 12.37 |
| Clay | 12.37 |
| Flint | 34.51 |

Crucibles and other articles of laboratory use prepared in this manner are said to be more serviceable and durable than glazed porcelain which they resemble in appearance. The thermal conductivity is greater than that of porcelain, which permits of quicker and more economical heating and reduces the strain in the walls during heating and cooling. (1,081,542, Dec. 16, 1913.)

## The Parral Tank System in the Leaching of Copper Ores

In view of the wide interest attached at present to the treatment of copper ores by leaching with acids, the application of the Parral agitating tank for this purpose, is of particular interest.

The Parral tank was first used in Mexico in cyanide practice as fully described in our Vol. X, pp. 48 and 434, replacing the Pachuca tank. If we compare the Parral and Pachuca tanks the objectionable height of the Pachuca tank is avoided in the low form of the Parral. In the Pachuca tank a definite ratio of height to diameter must be preserved, while in the Parral no cognizance of this ratio need be taken.

In the Parral tank system the agitation is effected by a plurality of transfer pipes of comparatively small diameter through which the continuous transfer of the pulp from the bottom to the top of the tank is brought about by compressed air. Compressed air is admitted to the bottom of these transfer pipes through a nozzle fitted with a ball valve which automatically opens and closes as required in the jet feeding of compressed air. The discharge ends of the transfer pipes are horizontal and so directed that the discharging pulp will spout in the same direction with respect to the interior side of the tank and in line with segment cords thereto. This method of discharge sets up a rotary current in the tank charge which flows round and round within the tank and keeps the whole charge in rotary motion from top to bottom of tank.

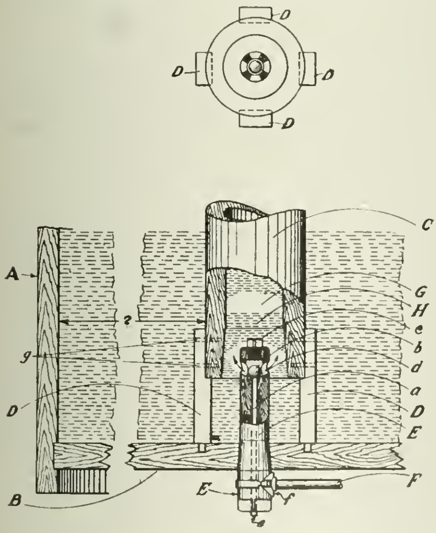


FIG. 1—AIR NOZZLE AND AGITATION PIPE FOR ACID SOLUTION

If the Parral tank is to be used in copper metallurgy for the treatment of slimes and flue dust in acid solutions, the tank, the transfer-pipes, and the air-nozzle are made entirely of wood and the ball in the air-nozzle is made of glass so that all the material used is acid-proof. Fig. 1 illustrates the arrangement for acid leaching, showing a corner of the tank, one transfer-pipe, the wooden air-nozzle with the compressed air pipe attached thereto and the glass ball seated on the compressed-air axifice to prevent the entrance of the said solution when the air is off.

*A* are the staves of the tank side, *B* the bottom of the tank, *C* the transfer-pipe, *D* the wooden legs supporting the transfer-pipe, *E* the compressed air-nozzle inserted up through the bottom of the tank, *F* the wrought iron compressed-air pipe attached to the wooden nozzle by a strap flange, *G* the compressed-air disc in the transfer pipe, *H* the alternating pulp sections carried upwards between the air-discs.

The air hole bored through the nozzle is shown at *a*, while *b* is the glass ball which closes the air nozzle and prevents the entrance of the acid solution; *c* is the top screw plug which closes the top of the air nozzle after the ball is dropped in; the four vents through which the compressed air enters the transfer pipe are shown at *d*.

This apparatus can be cheaply installed in any wooden tank and, as the illustration shows, the removal and replacement of an air nozzle may be quickly and easily effected.

With this equipment the settlement of the pulp after agitation, the decantation of the pregnant solution, a second dilution of the pulp with weak solution followed by reagitation, a second settlement and decantation followed by final water-wash of the pulp may be carried on in the same tank when properly equipped for the purpose, or it may be carried on in stages in different tanks if so desired.

The patents of the Parral tank system are owned by Mr. Bernard MacDonald, 1005 Fair Oaks Avenue, South Pasadena, California.

## Personal

Mr. **T. F. Baily**, president of the Electric Furnace Company of America, of Alliance, Ohio, delivered recently before the Pittsburgh Foundrymen's Association on his "electric furnace for reheating and annealing as applied to steel foundry practice."

Mr. **J. M. Callow**, of the General Engineering Co., Salt Lake City, Utah, is in charge of the construction of the new concentrator for the Magna Copper Co., Superior, Ariz.

Mr. **Angus Cameron**, president of the Radium Company of America, Sellersville, Pa., is traveling in the West and will visit the mining sections in Colorado and Utah, where his company have interests and stations, and will personally deliver parcels of radium. The policy of this company is to furnish their radium to medical practitioners in the United States.

Mr. **J. E. Clennell** is on the technical staff of Charles Butters, and is in charge of the new testing laboratories lately established in San Francisco.

Mr. **William M. Corse**, the well known secretary of the American Institute of Metals, has severed his connection with the Lumen Bearing Co. to associate himself with the Empire Smelting Co., of Depew, N. Y., in the capacity of general manager.

Mr. **Louis Emanuel** is superintendent of the smelter of the Arizona Consolidated Copper Co., at Humboldt, Ariz.

Mr. **O. A. EnHolm** has severed his connection with the Electric Heating Apparatus Co., and is devoting his time to his own personal matters and experimental work.

Mr. **Ernest P. Humbert**, of Niagara Falls, N. Y., formerly assistant of Dr. Paul Héroult, delivered recently before the Pittsburgh Foundrymen's Association an address on "the electric steel refining furnace in the foundry."

Mr. **O. C. Schaefer** has been selected as operating superintendent of the mill of the National Radium Institute, now being built in Denver.

## Digest of Electrochemical U. S. Patents

PRIOR TO 1903.

*Arranged according to subject-matter and in chronological order.*

*Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.*

### REFINING METALS (*Continued*).

625,864, May 30, 1899, Emil Wohlwill, of Hamburg, Germany.

Relates to the electrodeposition of gold, and refers to his prior application which became patent 625,863. The present patent differs from that in that a part or all of the hydrochloric acid is substituted by a soluble chloride capable of forming a double salt with the gold, such as sodium chloride. The electrolysis is preferably carried at 60° to 70° C.; the quantity of chloride added is increased with lower temperatures, or with increased current density. In view of the solubility of silver chloride in sodium chloride, the latter should not exceed 100 grams per liter. In the presence of platinum and iridium, potassium chloride or ammonium chloride should not be used.

636,321, Nov. 7, 1899, Thomas Craney, of Bay City, Michigan.

Relates to the extraction and deposition of copper from large masses or boulders of native copper, such as are found in the Lake Superior District. Such masses of copper sometimes weigh from twenty-five to one hundred and fifty tons, and owing to their shape cannot be profitably mined. A suitable cavity is made in such a mass and filled with an electrolyte such as acidulated copper sulphate, the mass of copper is connected as anode, and a cathode inserted in the electrolyte. During the electrolysis, the cavity is occasionally cleaned to remove any slimes which may contain gold or silver, a fresh cathode inserted, and the operation continued.

657,119, September 4, 1900, Frank Klepetko and John T. Morrow, of Great Falls, Mont.

Relates to the deposition of copper. States that if to a solution of copper sulphate containing twelve parts by weight of sulphuric acid, fourteen parts by weight of copper sulphate, and seventy-four parts of water, about one or two per cent by weight of wood-tea is added, the deposited copper is smoother, denser, and purer; its character being materially changed and improved. The wood-tea further serves to lessen the influence of the antimony, in that the latter may be allowed to accumulate to a much larger extent without contamination of the deposited copper. The wood-tea may be prepared by soaking wood in water highly heated by steam.

669,439, March 5, 1901, Hans A. Frasch, of Hamilton, Canada.

Relates to apparatus for carrying out the process described in his copending application which became patent 669,440. The apparatus consists of a tank with a brick-lined bottom, in which are tile gratings through which the electrolyte enters. Passing through a side of the tank are a plurality of anodes of carbon, located between the tile gratings. Upon the bottom, and covering the anodes, is placed the suitably ground matte or ore containing the metal to be extracted. Above the matte is placed a layer of sand as a diaphragm. The cathodes project into the space above the sand. The electrolyte is drawn off from the upper part of the cell and circulated through the matte and in contact with the anodes.

669,440, March 5, 1901, Hans A. Frasch, of Hamilton, Canada.

Relates to extracting such metals as copper, nickel, cobalt, etc., whose hydroxids are soluble in ammonia, from their matte, ores, etc., containing them. The matte or ore is suitably ground and spread over the bottom of a tank in contact with carbon anodes. Through the mass of matte, etc., is percolated a solution of a salt of ammonium, such as ammonium sulphate; this solution is decomposed by the electric current, the anions combining with the metal to be extracted in the matte, and forming a double salt with the excess of ammonium salt. Above the layer of matte is a diaphragm of sand, etc. Above this is a large volume of electrolyte from which the metal is deposited upon suitable cathodes. The ammonium salt electrolyte is then withdrawn and supplied to the lower layer of matte, etc. The patent contains a reference to his copending application for the apparatus which became patent 669,439.

## Book Review

**De Re Metallica.** By **Georgius Agricola.** Translated from the First Latin Edition of 1556, by **Herbert Clark Hoover** and **Lou Henry Hoover.** Quarto (20 x 33 cm.), 637 pages, numerous illustrations from the original. Price in America $8, in England 25 shillings. London: The Mining Magazine. San Francisco & New York: The Mining & Scientific Press.

At the annual meeting of the Mining and Metallurgical Society of America, in New York City, January 13, the annual medal of the society was awarded to Mr. and Mrs. Hoover, in recognition of this great contribution to English metallurgical literature. This is timely and well-deserved recognition of a great literary task splendidly completed.

Heretofore this patriarch of books on mining and metallurgy has been practically inaccessible to the English technologist. We do not wish it inferred that the mining engineer or metallurgist has been thus deprived of a great technical vade mecum, but he has been cut off from a clear and highly interesting account of the beginning of modern mining and metallurgy. Just as a great picture must be viewed from one certain standpoint in order to see all its parts in their proper proportion and perspective, so the literature of mining and metallurgy focuses to the vanishing point in the book of Agricola, and needs to be viewed from this starting point in order to be seen in proper perspective. The possession of this translation completes the literature of mining and metallurgy, in English, at the beginning; the other end is perpetually being finished, up to date, but will never be completed.

To every one who knows and loves mining and metallurgy, we say "get this book, and love it more." It is like getting personally acquainted with one's ancestors. Relatively in the dark regarding the correct principles of mechanics, physics and chemistry, yet these old practitioners teach us many lessons of patience, perseverance, common sense and skillful adaptation of means to ends. Inferior to us only in the knowledge (most of which is not to our personal credit), they were certainly our equals and often our superiors in applying what they did know to useful ends. The essentially human achievements of these old practitioners give us a fraternal feeling across the three and a half centuries which makes us proud to call ourselves their successors.

The explanatory technical notes added by the translators are simply admirable.

We wish to add our congratulations to those which are coming from all sides to the distinguished translators. Their achievement may properly be included in Fabricius's eulogy of Agricola's work: "Death comes to all, but great achievements raise a monument which shall endure until the sun grows cold."

# Metallurgical and Chemical Engineering

A Consolidation of ELECTROCHEMICAL AND METALLURGICAL INDUSTRY and IRON AND STEEL MAGAZINE

VOL. XII NEW YORK, MARCH, 1914 NO. 3

PUBLISHED MONTHLY BY THE
McGraw Publishing Company, Inc.
JAMES H. MCGRAW, President.
C. E. WHITTLESEY, Secretary and Treasurer.
239 West 39th Street, New York.
TELEPHONE CALL, 4700 BRYANT.
CABLE ADDRESS, METCHEM, NEW YORK.

WESTERN OFFICE................421 Boston Bldg., Denver, Colo.
CHICAGO OFFICE.........................Old Colony Building
PHILADELPHIA OFFICE...............Real Estate Trust Building
LONDON OFFICE.............Hastings House, Norfolk St., Strand

E. F. ROEBER, PH.D., Editor.
H. C. PARMELEE, Western Editor.

J. M. MUIR, Manager.

*Yearly subscription price for United States, Mexico and United States dependencies,* $2.00; *for all other countries,* $2.50. (*European exchange,* 10 *shillings,* 10 *marks,* 12.50 *francs.*)

Copyright, 1914, by the McGraw Publishing Company, Inc.

Entered as Second-Class Matter at the Post Office at New York, N. Y., under the Act of Congress, March 3, 1879.

NEW YORK, MARCH, 1914

CONTENTS.

EDITORIAL:
- Fiftieth Anniversary of the School of Mines of Columbia University .... 168
- The Laws of Crushing .... 143
- The Statistics of Pig Iron Production .... 143
- Improvements in Copper Converting .... 144
- How the World Pays for Engineering Progress .... 144
- The Proof of Puddings and Processes .... 145

READERS' VIEWS AND COMMENTS:
- Concentration of Carnotite and the Work of the Bureau of Mines. By Siegfried Fischer .... 146
- The Induction Furnace—Its Efficiency and Refining Capabilities. By William Bjorkstedt .... 147
- The Patent Processes for Making Casing Head Gasolene. By H. O. Chute .... 147

Iron and Steel Market .... 148
The Western Metallurgical Field .... 149
Mechanical Refrigeration—II. By H. J. Macintire .... 151
The Manufacture and Uses of Blaugas. By Hugo Lieber .... 153
Notes on the Gran-Annular Electric Furnace. By Zay Jeffries. 154
Concentration of Complex Sulphide Ore from the Mary Murphy Mine. By Dyke V. Keedy .... 157
Resistivity of Brass, Solid and Molten. By Edwin F. Northrup .... 161
Industrial Synthetic Production of Sodium Cyanide. By Camille Matignon .... 163
Electrometallurgy of Iron and Steel. By Woolsey McA. Johnson .... 165
Analysis of Natural Gas. By W. D. Brown .... 168
Radium Hearing at Washington .... 170
The Boiler Plant of the Blast Furnace. By J. E. Johnson, Jr. 171
NOTES ON CHEMISTRY AND METALLURGY IN GREAT BRITAIN .... 179
Symposium on the Undeveloped Elements. (Papers by Charles Baskerville, H. T. Kalmus, E. Weintraub, and R. W. Moore) 181
An Apparatus for Making the Flash and Fire Tests of Lubricating Oils. By H. L. Siever .... 188
Mining Engineers' New York Convention .... 189
- Nipissing Mill and Metallurgical Practice. By Jas. Johnston 189
- Oxygen in Cast Iron. By J. E. Johnson, Jr .... 192
- Heat Treatment of Steel Castings. By C. D. Young, O. D. A. Pease, and C. H. Strand .... 193

RECENT CHEMICAL AND METALLURGICAL PATENTS .... 194
SYNOPSIS OF CHEMICAL AND METALLURGICAL LITERATURE .... 197
Pressure Air-Cooled Roaster Furnace .... 199
Laboratory and Sample Mill .... 200
New Base-Metal Thermocouple .... 200
A New Chemists' Slide Rule .... 201
A Self-Cleaning Screen for Sewage and Trade Wastes .... 202
Apparatus for Determining the Hardness of Metals by the Brinell Method .... 205
Anti-Corrosion Pickling Chains and an Acid-Pump Casting .. 206
Weighing and Regulating the Continuous Flow of Materials on Conveyors .... 206
The Application of Producer Gas to Glass Factories .... 207
Pneumatic Type Recording Tachometer .... 207
Chart Recording Instrument .... 208
Electric Steel Melting .... 209
The Non-Ferrous Metal Mkt .... 209
PERSONAL .... 209
DIGEST OF EECTROCHEMICAL U. S. PATENTS .... 210
BOOK REVIEWS .... 211

## The Laws of Crushing

Will someone with a mathematical mind and a practical knowledge of the art of crushing rock, volunteer to sacrifice himself in the interests of science by attempting a satisfactory solution of the vexed question as to whether the laws of Rittinger or Kick apply in the work of crushing? Is the work of crushing proportional, respectively, to the reduction in diameter of the particles, or does it vary as the volumes and weights of these bodies?

There are staunch advocates of both of these contentions. Stadler, of South Africa, is firm in the support of Kick's law; and recent investigators at McGill University in Canada are said to have arrived at similar conclusions. More recently Taggart, of Yale, has taken the same stand. On the other side, Del Mar and Gates and Robert H. Richards have publicly supported the law of Rittinger, which Stadler says is a myth resulting from a misinterpretation of Rittinger's words.

This leaves us in suspense. From Rittinger and Kick on down to the latest convert, the various advocates have commanded respect for their knowledge and ability. And yet on this point they are in disagreement and have divided an otherwise united following into two camps. The way is open for someone to harmonize the two factions. In the meantime the mechanical efficiencies of crushing machines and the power consumed in the work of crushing will remain moot questions until agreement is reached as to the proper method of calculation.

## The Statistics of Pig Iron Production

Of the 30,966,301 gross tons of pig iron produced in the United States in 1913, 16,738,952 tons, or 54 per cent., was delivered in molten condition, according to the official statistics issued the middle of February. The quantity of iron other than Bessemer and basic disposed of in molten condition is negligible, while the tonnage of Bessemer and basic produced amounted to 23,814,313 tons, of which the molten iron reported is 70.3 per cent. This indicates a very large employment indeed of direct furnace metal, since owing to the exigencies of Sundays and holidays, as well as blast furnaces running ahead of their attendant steel plants, it is necessary to cast considerable pig iron at plants which regularly use direct metal. It is probably safe to conclude that between 80 and 85 per cent. of the total steel production of the country is made at plants which regularly use the direct metal process, the remaining steel being made at detached steel works which use cold pig, usually purchased in the open market.

The segregation of pig iron into the forms in which cast or delivered commenced only with the year 1912, so that comparative statistics are lacking to show the growth of the direct metal process, but it is well known that it was not used in plants which produced as much as half the total steel production. The statistics returned are as follows, "chill cast" meaning simply iron which was cast in loose chills, set by hand, instead of in chills carried mechanically:

| | 1912 | 1913 |
|---|---|---|
| Molten condition | 16,466,722 | 16,738,952 |
| Sand cast | 6,309,495 | 6,689,680 |
| Machine cast | 6,214,121 | 6,522,075 |
| Chill cast | 6,726,017 | 1,000,172 |
| Direct castings | 10,582 | 15,422 |
| Total | 29,726,937 | 30,966,301 |

An improvement is introduced in the 1913 statistics, by the segregation of merchant pig iron. The tonnage made for sale is given at 9,734,238 tons, the quantity made for the use of the producers being 21,232,063 tons. The latter item is made up almost exclusively of pig iron made by the regular steel interests, and includes almost all of the 16,738,952 tons reported as delivered molten.

The production of pig iron in 1913 established a new record, passing the 1912 output by 1,239,364 tons, or 4.2 per cent. The year 1906 stands out as the last year during which there was full production throughout the year, the 25,307,191 tons produced in that year representing substantially the full capacity of the furnaces in existence. In 1913 there was not full employment of the existing furnaces, yet there was a gain over 1906 of between 22 and 23 per cent. in the tonnage output. This, however, was quite a moderate gain for pig iron in seven years, seeing that in the past production has usually doubled about once in ten years. However, the 1913 production was nearly double that of 1901, and as much more than double the output in any year previous to 1901. The present capacity may be taken as between 34,000,000 and 35,000,000 tons, or 3,000,000 to 4,000,000 tons in excess of the actual output last year. This estimate of capacity is based upon the possibilities of actual commercial performance, with raw materials and finished products selling at moderate, but not ordinarily profitless prices. The physical capacity, including furnaces which can operate profitably only when there is a very wide margin, is perhaps several million tons greater.

## Improvements in Copper Converting

Basic-lined copper converters have practically superseded those with acid lining, with attendant great increase in the duty per lining. Practice has changed radically, from providing a lining which was intended to be consumed, to one presumed to be chemically inert under the conditions existing in the converting process. The present tendency is to make every effort to protect the lining from destruction and to supply from without the necessary fluxing ingredients to convert the matte to blister copper.

In this connection the recently patented idea of Messrs. A. E. Wheeler and M. W. Krejci, of Great Falls, Mont., bids fair to have a wide influence on the metallurgy of copper. They coat the basic lining of a converter with a layer of magnetite so that no portion of the lining is exposed, and is thus protected from destruction. This protective layer is formed synthetically when the converter is first placed in commission and its thickness is thereafter controlled by attention to details of operation. The principle involved is that the blowing of matte with a deficiency of silica results in the formation of magnetite.

When a converter is operated in accordance with the idea of Wheeler and Krejci, its basic lining receives a monolithic coating that prevents mechanical or chemical disintegration, unless improper converting temperatures are employed. The magnetite coating has a melting point some 300° C. higher than the temperature at which converting takes place, which is a good margin in favor of the maintenance of the coating. And since the deposition of magnetite can be controlled by regulating the proportion of silica supplied to the matte, a converter once lined and coated should, in theory, never require relining. Practically the effect is to greatly prolong the life of the converter and to reduce converting costs by securing greater duty per lining.

Basic linings of magnesite brick in copper converters have been in use only a few years, but during that time they have abundantly proved their superiority. Steady improvement in the process of basic converting has followed the successive adoption of the method at Baltimore, Garfield, Anaconda and Great Falls. Basic linings protected as above described have lasted over two years, which is in marked contrast to former practice, either acid or basic. The patent claims on the process are broad, not being restricted to the deposition of magnetite on basic linings, but generally to the process of forming monolithic furnace linings by the oxidation of base-metal components of the converter charge.

## How the World Pays for Engineering Progress

The subject of the cost and price of any commodity is one of the most difficult in the science of economics. In practical affairs, between buyer and seller, it is likewise a hard proposition. But it is logical to conclude that the cost of production is the integrated amount of human effort measured in terms of "mendays"—for the work of the unskilled laborer for one day is a proper and sound unit for such a purpose—which is given by the world in the production of the commodity under question. To measure this amount is quite another question. We suppose it is natural to assume that the average price less a certain profit apportions this accurately. In the final analysis, there exists a certain charge more or less incommensurate but still actual. This charge is the price the industry pays for the immense amount of unproductive experimenting.

The fact that the community pays for the failures of any enterprise is shown by the remark so often made that it costs more to mine gold than the gold is worth and that the losses of the failures are not paid for by the profits of the successes. We believe that this is not strictly true but that there is an element of truth in it, and that it is widely true that the high profits derived from successful attempts to gain mineral wealth include insurance against failure. Mining engineers who lay the proper stress on the commercial side of mining insist that mining stocks should return from 10 to 20 per cent on the market value to allow for the exhaustion of mineral and to recompense the investor for previous losses. This is only right.

It is plain that the same conditions hold in the case of a reduction works that treats a crude mineral and produces a commodity useful to the community. There is always change, for the only thing unchangeable is human mutability. After countless failures a successful new process brings it about that the old plants must be "scrapped." So we see that in the constant flux of metallurgy there is always progress and that new processes when "practicalized," thereby render the old plants obsolete and make mines of deposits whose ores were commercially unavoidable. This, of course, has the effect of annihilating or at least depreciating the value of existing plants.

In any proper system of accounting there should be a charge to cover this loss. In electrical engineering where progress is rapid and sure this is set down under the item of "depreciation due to the advance in the state of the art." We have pointed out that in metallurgical engineering the changes proceed slower and with less apparent certainty than in electrical engineering, due to the fact that "commercial inertia" is greater in the former art than in the latter.

But in the metal business, progress though seemingly slow and made by saltations, is none the less an inexorable condition of existence. It is, moreover, costly and the world pays the reckoning in the price it pays for iron, copper, lead, zinc, and the other metals.

It is well known that pioneers in the introduction of any new process struggle along now intelligently, now aimlessly, and only attain progress by perseverance. We have the word of Sir Roberts-Austen that Sir Henry Bessemer made seventeen different types of steel converters before he hit upon a satisfactory and practical form of apparatus. Then, too, it was much improved by Holly and others in America.

It seems to be indubitable in view of the great amount of time, human energy, and money expended in the endeavors to "practicalize" new processes, that in any broad analysis of metal prices and metal costs, the consumer finally pays for all of it. For instance, take the case of improvements in the metallurgy of complex zinc-lead sulphides. A low estimate of the cost of attempts to develop the alluring hydrometallurgical processes, whose name is legion in association with that of zinc, is $15,000,000. In one sense this is all wasted. But in no other way does the world learn what can be done and what cannot be done, and if a successful process of any kind be developed, the returns to the world will be vastly greater than $15,000,000.

We see in the evolution of the fauna and of the flora that nature shows an equal and similar ruthlessness. She progresses slowing, evolving out of her wayward children the "sports," which are variations from the normal of existing species, a new type that is fitted to the new environment. But hardly one out of the myriad of "sports" is the successful variant that is the ancestor of the type of the future. There is, or rather there seems to be, a vast amount of unintelligence in the means by which nature progresses.

To have seen clearly in this apparent unintelligence, an ever-present intelligence that guides the force of nature, this must be placed to the credit of Henri Bergson and explains his immense present popularity among philosophizing humanity. This French Jew has superinduced upon the naturalistic philosophy of Herbert Spencer a lofty and noble spiritualistic superstruction. He typifies in his clear-cut idealistic thought, harmonizing so accurately the emotions and reason, the genius of his race and the genius of his country. He shows in his "Evolution Creatrice" that nature is really the embodiment of intelligence and that evolution is broadly constructive rather than narrowly destructive. His argument is at once sound and as brilliant as are his conclusions inevitable.

On the analogy of his philosophy we see a similar process going on in metallurgy. The useless experiments are unintelligent in one light and intelligent in another light. The sum total of all is progress and progress is the result of the victory of intelligence over inanimate obstacles. Continuing the line of Bergson's thought, it is reasonable to expect that the increased diffusion of applied science will tend to make the cost of progress less and to decrease the bill that civilization charges its inhabitants for metals, the sinews of its warring existence.

---

## The Proof of Puddings and Processes

An old proverb gives a concise and positive rule for determining the value of a certain product of the culinary art, advising us that only in the eating of a pudding are we to find absolute proof of its worth.

In view of the many new chemical and metallurgical processes constantly seeking public favor, it seems proper to paraphrase the above proverb and say that the proof of a process is in the bookkeeping. Good metallurgy lies in making money out of ores, and processes which do that successfully have value. It matters not how ingenious a process may be, nor is it always of consequence that the chemistry and mechanics involved are correct; if the net result is not going to yield more dollars than are spent, the process has no commercial value.

One difficulty in arriving at the value of inoperative processes is that actual figures are not available to show the costs of the various steps. And unless an engineer has data gleaned from similar steps in other allied industries he cannot arrive at a safe approximation of profit and loss. If the proposal is wholly novel its cost may be roughly estimated, but in some cases nothing but an actual test, carefully checked by weights and assays, will reveal the truth. The intrinsic meaning conveyed by the old proverb is a good guide in valuing processes.

# Readers' Views and Comments

## Concentration of Carnotite and the Work of the Bureau of Mines

*To the Editor of Metallurgical and Chemical Engineering:*

Sir:—In your issue of February, 1914, I note an extract from Bulletin 70, Bureau of Mines, on the "Concentration of Carnotite by Wet and Dry Methods." According to both the government bulletin and the extract in your journal, it would seem as if the work on concentration of carnotite ores was made public for the first time in the preliminary report by Dr. Moore and Dr. Kithil. This, however, is incorrect.

Up to within the year 1912, it was considered a practical impossibility to concentrate said ore, due to its very fine physical structure. In a report printed by the Colorado Bureau of Mines, 1905, you will find this statement substantiated by Messrs. Fleck and Haldane of the Colorado School of Mines. After some personal research during 1911 and part of 1912, I was convinced that the wet concentration of carnotite ores was a commercial possibility. The results of my investigations, giving data, describing process, and showing the advantages gained by such an operation was published in Metallurgical and Chemical Engineering, in June, 1912, fully one and one-half years previous to the Bureau of Mines' Bulletin 70.

Siegfried Fischer.

Metallurgical Department, Lehigh University,
So. Bethlehem, Pa.

## The Induction Furnace—Its Efficiency and Refining Capabilities

*To the Editor of Metallurgical and Chemical Engineering:*

Sir:—In your February, 1914, issue Mr. I. Rennerfelt has brought up a few questions which it might be worth while to discuss a little further as there seems to exist quite some confusion regarding same. I mean the efficiency of various types of electric furnaces and the possibility of refining in induction furnaces. In the following I will confine myself to induction furnaces as I am more familiar with these than with "arc resistance" and "arc radiation" furnaces.

As regards the variance of information regarding the first point it is probably explained by saying that usually not all the factors are taken into consideration in calculating efficiencies and that various statements regarding "efficiency" are not directly comparable as they are based on different assumptions.

When a certain efficiency is stated, the conditions of operation as well as size of furnace, etc., should also be stated.

In the following I will first give an example showing that the efficiency of a furnace will be different under different conditions of service. The figures used are not quoted from furnaces in operation, but merely assumed to illustrate this fact.

Assume that a 20-ton induction furnace is used for melting cold scrap and that the theoretical power consumption per ton of steel which, of course, is the same under all circumstances, is 460 kw-hr. per metric ton; further, that the radiation loss of such a furnace is 7500 kw-hr. per twenty-four hours, and the electrical loss 3 per cent.

Assume also that in Case "A" 70 tons are melted per day, and in Case "B" 50 tons per day.

| | *A* K.W.H. | *B* K.W.H. |
|---|---|---|
| Theoretical power consumption per day, about | 32,000 | 23,000 |
| Radiation loss per 24 hrs., about | 7,500 | 7,500 |
| Electrical loss at 3 per cent, about | 1,200 | 940 |
| Total | 40,700 | 31,440 |
| K.W.H. per ton | 580 | 630 |
| Efficiency | $\frac{32,000}{40,700} = 79\%$ | $\frac{23,000}{31,440} = 73\%$ |

As will be seen, the efficiency in the first case is 79 per cent, in the second case it is 73 per cent. I wish to point out that when a certain efficiency is stated, it must always be explained what is meant by it.

If, on the other hand, someone makes similar calculations as above, but instead of regarding the efficiency as has been done here, he means by these terms the ratio between the power consumption per ton of steel figured out and the actual amount arrived at in practice, which might be somewhat higher on account of inaccuracies in the figures assumed, say 15 per cent higher, he will then state that the efficiency is 85 per cent in both cases.

Regarding the other point, the possibility of refining steel from phosphorus and sulphur and deoxidizing it in induction furnaces, I agree with Mr. Rennerfelt that the engineer who is not an electrometallurgist might be bewildered by the different statements made in this respect. As far as I am personally concerned, I am perfectly satisfied with the knowledge that there is no difficulty at all to refine in induction furnaces, and I wish to make a few remarks which might explain a number of things.

When Kjellin for the first time made steel commercially in an induction furnace in Gysinge, he made use of a furnace consisting merely of a circular channel containing the steel wherein the heat was generated. This channel was covered with lids. Now in order to refine steel for the removal of phosphorus and sulphur the following operations have to be performed:

The steel is first to be covered with an oxidizing slag which absorbs the phosphorus; this slag has to be removed and a new basic slag added to absorb the sulphur. In order to remove the first dephosphorizing slag from the steel in the Kjellin furnace the lids had to be removed and the slag lifted up. When the lids were removed a very large amount of heat escaped, the slag cooled off, and, of course, it was very difficult and time-wasting to remove the slag by lifting it up. It was hardly possible to remove it all. Consequently it was hardly possible to remove the phosphorus since during the following deoxidizing and desulphurizing operations the phosphorus absorbed in the slag, remaining in the furnace, was again reduced and entered the steel again.

The information was, therefore, spread broadcast that the induction furnace could not be used for refining, and also that the slag was not sufficiently fluid. This was true in regard to the first Kjellin furnace whereas in the Roechling-Rodenhauser furnace and the improved type of double-ring Frick furnace there is no difficulty at all in refining the steel or keeping the slag fluid, especially when they are made tilting, and with lateral doors, which latter arrangement goes a long way toward decreasing radiation losses.

As regards the statements made several times that the slag must be like a watery liquid and overheated to a high degree in order to be able to absorb sulphur and hotter than the steel, I think these are exaggerating statements. The only condition necessary, with the exception, of course, of conditions as to composition of slag, etc., is to have the temperature at the surface between the steel and the slag, which is the place where the reactions take place, sufficiently high. Even assuming that it should be necessary to keep the slag in a watery condition, this can be done in an induction furnace by merely increasing the temperature in the furnace. Of course, the steel will also get hotter, and it has been said that it will be overheated. What is the meaning of this? The steel covered by a protecting layer of deoxidized quiet slag which, at no point allows possible air or oxidizing gases present to attack it, cannot possibly be injured by a very high temperature derived from the heat which is generated in the steel itself.

William Björkstedt.

New York City.

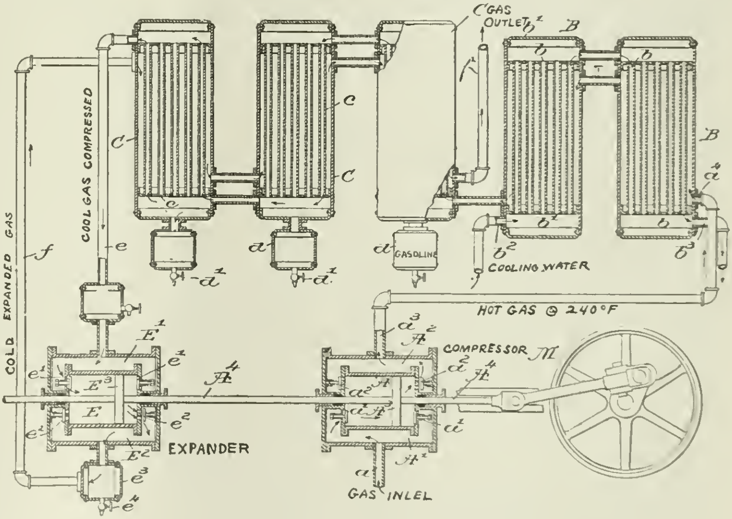
---

## The Patent Processes for Making Casing Head Gasoline

*To the Editor of Metallurgical & Chemical Engineering:*

Sir:—Within the last few years the industry of producing gasoline and light boiling fluids from casing head gas and some natural and artificial gas has become a large industry and many patents on the subject have appeared and many patented processes are being developed. In some cases the patents have only been applied for and in others patents have been granted.

Under our patent system each application is examined to ascertain whether the applicant has any invention and no matter how small a part of a process an invention is, a patent may be obtained on this new feature. This novelty may be actually useful or necessary to success or it may be only asserted to be useful by the applicant. No question is usually raised as to usefulness of a patent by the patent office, as it is left for future development to show that. One may also secure a patent and yet not be able to use it on account of the prior patents dominating him. Also the patent office examination is not accepted by the courts as complete or really having much weight and when the patent is litigated in the courts a prior patent may be held to render the later one invalid.



DRAWING OF HEINZERLING APPARATUS

On this account a prospective investor in patents must know something of the previous patents and what is known as "the state of the art."

A brief review of the art and patents should therefore be of timely interest.

Of course, it has always been known that there were so-called "wet gases," particularly among the "casing head" gases or those coming from a well in which oil was also produced. It was known that the gas contained oil and that the oil contained gas. The patent to Grieg and Smith, No. 42,121, of 1864, states that "Petroleum on being taken from the wells contains a large quantity of gas which when separated from the oil can be used for fuel."

This patent only discloses a method of ridding the oil from gas by blowing air through it.

In 1866 Johnson received patent No. 54,917, which clearly discloses the art of "rendering liquid the vapors which rise with or are forced up with petroleum." These are "light benzine, naphtha, etc."

The specification discloses the compression of the vapors by means of "lift or force pump" . . . "connected to a suitable condenser from which I gather the condensed liquid products into barrels," etc.

He states: "I employ power to actuate the pump."

His claims include "a new article of commerce, viz., the light condensable vapors which rise with petroleum and which may be pumped off under any suitable seal and condensed."

Here is clearly disclosed the primary operations of compressing casinghead gas and condensing out "the light benzine, naphtha, etc."

Consequently there can be no patents in existence which dominate the two primary operations necessary to produce casinghead gasoline.

In carrying on any commercial operation, economy is, of course, necessary and apparatus working in an economical way is, of course, an essential, but in the Heinzerling patent of 1897, No. 575,714, which expired Jan. 28, 1914, there is shown an air compressor or gas compressor cylinder and a gas expansion cylinder, both coupled to a flywheel with a series of condensers and heat exchangers between. The specification clearly explains that the gas is to be compressed in the first cylinder and cooled in two condensers in series; with condensation of the condensable liquids, which are removed by appropriate valved containers depending from and connected with the condensers. Thence the water-cooled gas passes to other condensers cooled by the residual gas which is meantime expanded in the second cylinder, which thus aids the compression. The expansion produces cold gas which afterwards, circulating through the last condensers, cools the compressed gas to a point stated to be between —25 and —40 deg. C. The first water cooling refrigerates the gas, as stated, to 10 deg. C.

Furthermore, this patent discloses the cooling of the gases by direct contact with cooling liquids such as calcium chloride and glycerine.

It states that "petroleum, benzine" and some others are not soluble in glycerine. The patent states "this method of direct cooling by liquids is limited, as the substance to be separated must be insoluble in the liquid."

While this patent is not specifically directed to the production of casinghead gasoline, as the applicant was a German who probably never knew anything about this gas, yet the patent covers broadly any gases containing a volatile liquid, and the same machinery and process can be used on any gas, and no subsequent patent can claim any special gas unless it is shown that the special gas acts differently than any described in the patent.

It would appear, therefore, that the field is open to anyone to produce casinghead gasoline by using compression and condensation broadly or to use compression and water cooling on a gas and to subsequently expand the gas in a steam cylinder to help the compressor along, and that while compressing, the gas may be cooled with water, calcium chloride or glycerine, and further that the expanded gas may be used to cool the compressed gas by means of any heat interchanger.

In most of the processes now in successful work all the necessary steps are comprised in the above enumerated steps, which are old, as disclosed by expired patents.

It is unfortunate that in the Government publications particularly "Technical Paper No. 10 of the Bureau of Mines," entitled "Liquefied Products of Natural Gas," published in 1912, no mention is made of the above patents, though an extensive bibliography is given in the back of the pamphlet of which very little before 1911 refers to natural gas. The knowledge of the contents of the above patents throws a light on the patent situation which cannot be gained from any of the references cited in the bulletin.

The existing patents will not be criticised in any way except to state that they must all be construed in the light of the previous art as shown by patents above cited which have expired.

Among the earlier unexpired patents is No. 668,197 of 1901, issued to Le Sueur, which claims a process of liquefying "methane" from natural gas. The process described would not seem to liquefy methane, but it would liquefy the higher hydrocarbons of the methane series found in the gas. This is shown by the following statement occurring in the patent: "For instance, the liquid may be produced in the first place (from natural gas) by high pressure and fractional distillation induced thereafter by relief of pressure." This patent therefore discloses the compression of natural gas and a subsequent fractional distillation of the liquids produced. This would seem to disclose a system of producing different liquid products by fractional distillation after condensation.

While the disclosure quoted is in the specification and not in the claims it is sufficient to invalidate any subsequent patents which might broadly claim this process.

In 1907 patent No. 867,505 was granted to Dennis Hastings and W. Brink. It discloses that natural gas "after being artificially compressed" is brought into contact with water which serves to cool the gas; later "water or oil" is "atomized" to "intermingle with the gas" to cool it. This discloses the use of a "washing oil" to condense the lighter oils of the gas. It further discloses separating the cooling fluid and the condensed gasoline. This process is not claimed, but is an estoppel of later patents. The claims are for an arrangement of apparatus.

In 1909 John L. Gray obtained a patent, 993,976, for certain apparatus for obtaining casinghead gasoline from the gas. The claims are for an organization of apparatus for separating, first, any engine or cylinder oil from the gas by means of the ordinary steam trap or oil trap used on steam lines; a condenser with another oil trap beyond and a relief valve which is an ordinary steam safety valve. There is also a pot steam trap to separate the condensed gasoline from the gas and a receiving tank.

Subsequent patents will not be commented upon, the intent of this article being to point out the things which are undoubtedly old in the art and which are free to the public.

H. O. Chute.

197 Pearl Street, New York City.

## The Iron and Steel Market

The buying movement in steel products referred to in last report has proved to be as satisfactory in results as was expected, since by early February it brought the steel mills up to an operation at an average of about 70 per cent of capacity, and this rate was maintained throughout the month, comparing with an average operation of about 55 per cent in January and an average of less than 50 per cent in December.

In February strictly new buying decreased somewhat, indicating, with the fact that the mills did not move up to operating at full capacity, that the increased buying of January was rather a temporary movement, caused chiefly by the fact that buyers acquired confidence in prices, after a decline of many months, and covered both to replenish their stocks and to provide a moderate tonnage for the future. A large part of the business booked was in the form of definite orders, with specifications attached, but there was also a fairly large volume of contracting, chiefly for first quarter, but in the case of bars, plates and shapes the majority of contracts were made to run through the second quarter also. Specifications against such contracts have been good during February, and the total volume of specifications for all steel products in February probably exceeded the aggregate for January, though as the latter part of January was much more active than the fore part, the average of February probably did not indicate as much pressure as the latter part of January.

With market conditions as they are at present the mills are not promised a heavier operation than 70 or 75 per cent in March or April, but in most quarters the interest of buyers in the market is expected to increase as time passes. The advent of spring is expected to bring heavier consumption in general, while it is believed that the railroads will soon have to buy more freely than they have in recent months. Thus far this year railroad material is estimated to have constituted between 10 and 15 per cent of the total tonnage purchased, whereas the normal requirements are estimated at about double this proportion. The matter of railroad buying is generally held to hinge upon the treatment accorded the railroads by the Interstate Commerce Commission, and particularly as to the case of the eastern railroads, demanding permission to make a general advance of about 5 per cent in freight rates. It is possible that the influence of the expected decision is being overestimated, as to its effect upon railroad policy in the long run, though there is no question that on account of the pendency of the advanced rate case the railroads adopted a definite policy of holding back their orders. While the advanced tariffs have been suspended until September 12, there is reason to expect a decision between May 1 and July 1, and there is increased expectation that some advances, if not the entire 5 per cent asked, will be allowed.

Monday, February 2, a great many announcements were made of advances in steel products. Some of the indicated advances held, while some did not. The American Steel & Wire Company advanced its prices $1 a ton, to a basis of $1.60 for nails, and the independents followed. About January 1 there had been a short period in which business was done on a basis of $1.50, the market later advancing to $1.55, and the effect of the advance to $1.60 has been to bring in specifications on $1.55 contracts. The National Tube Company advanced standard steel pipe one-half point, the independents promptly following, and this advance has had the effect of greatly increasing the volume of specifications on old contracts. Oil country goods were also slightly advanced. The majority of large steel producers announced an advance in bars, plates and shapes, naming 1.25c. as their lowest quotation on these products, for early delivery, with 1.30c. for second quarter contracts. It quickly developed that business could still be booked at the lower level, in the case of attractive tonnages, while second quarter contracts could be placed at 1.25c. The Carnegie Steel Company, however, did not recede, and still maintains 1.25c. as its minimum, while it will not sell farther than three months ahead, except on specific jobs. On bars and plates the 1.20c. price can easily be done with several mills for early shipment, while on structural shapes such a quotation is relatively infrequent.

### Pig Iron

The buying movement in pig iron which was clearly marked in January extended into the first week or two of February, the market afterwards becoming decidedly quiet. The buying was sufficient to advance the market fractionally, but was not of sufficient volume to require the blowing in of any number of idle furnaces. Resumptions of blast furnaces to date have been almost exclusively of steel works furnaces. It would appear that consumers as a rule are covered to April or July for tonnages equal to their present rate of consumption, while the operating furnaces are equally well sold up. There is no prospect of consumption decreasing, while any considerable increase would doubtless require the blowing in of additional furnaces, stocks being very light. The great majority of the furnaces now idle blew out before the market had reached a level as low as at present, hence it seems fair to assume that before many of them blow in a decided advance will be required. Coke has proved stronger than expected, while Lake Superior ore for the 1914 season may bring about as much as in 1913, whereas late last year the expectation was that there would be a reduction to the 1912 schedule, this meaning 65 cents reduction on Bessemer and 55 cents on non-Bessemer. The decline in pig iron seems to have discounted such a reduction in ore, and if a smaller reduction is made, or no reduction, the tendency would be for pig iron to advance. The market stands quotable as follows: No. 2 foundry, f.o.b. Birmingham, $10.50 to $11.00; No. 2 X foundry, delivered Philadelphia, $15.00 to $15.25; No. 2 foundry, f.o.b. furnace, Buffalo, $13.00 to $13.25; No. 2 foundry, delivered Cleveland, $13.75; No. 2 foundry, f.o.b. Chicago furnace, $14.00; at valley furnaces (90 cents higher delivered Pittsburgh); Bessemer, $14.25; basic, No. 2 foundry and malleable, $13.25; forge, $12.75. Imported ferromanganese has been advanced by stages from $35 to $39, Baltimore, with $2.16 freight to Pittsburgh.

### Steel

About the beginning of the month the leading mills advanced prices on billets and sheet bars a dollar a ton, to $21 for billets and $22 for sheet bars, with $1 additional for second quarter, f.o.b. maker's mill, Pittsburgh or Youngstown. A few odd sales have been made at these advanced prices, but in general consumers are well covered to April 1 and in exceptional instances there are contracts to July 1. Forging billets have stiffened materially and are generally held at about $26, Pittsburgh. Rods are $26, Pittsburgh.

### Finished Steel

Prices named below are f.o.b. Pittsburgh, unless otherwise stated:

Rails, standard section, 1.25c. for Bessemer, 1.34c. for open-hearth, f.o.b. mill except Colorado.

Plates, tank quality, 1.20c. to 1.25c.

Shapes, 1.25c.

Steel bars, 1.20c. to 1.25c., base.

Iron bars, 1.35c., Pittsburgh; 1.27½c. to 1.32½c., Philadelphia; 1.12½c. to 1.15c., Chicago.

Wire nails, $1.60 per keg, base; plain wire, 1.40c., base.

Sheets, blue annealed, 10 gage, 1.40c. to 1.45c.; black, 28 gage, 1.95c. to 2.00c.; galvanized, 28 gage, 2.95c. to 3.00c.; painted corrugated, 28 gage, 2.15c. to 2.20c.; galvanized, corrugated, 28 gage, 3.00c. to 3.05c.

Merchant steel pipe, ¾ to 3-in., 79 per cent. off list.

Steel boiler tubes, 3½ to 4½-in., 71 per cent. off list.

Standard railroad spikes, 1.45c. to 1.50c. Pittsburgh, 1.50c. to 1.55c., Chicago.

Structural rivets, 1.70c.; boiler rivets, 1.80c.

Cold rolled shafting, 64 per cent. off list.

---

## The Western Metallurgical Field

### Developments at Leadville

Ever since the discovery of zinc carbonate ore at Leadville there has been talk about building a treatment plant there to handle the low-grade ores that could not be shipped to the smelters in the Middle West. It is definitely known that there is a considerable tonnage of such ore, containing from 14 to 18 per cent zinc, that has not been salable. In the aggregate it could support a treatment plant, provided a profitable metallurgical scheme could be devised, and several individuals and companies have considered the feasibility of entering this field. Hydrometallurgical processes have been tested, and pyrometallurgical concentration prior to smelting also has been proposed.

Within the past thirty days, however, the possibility of erecting a treatment plant at Leadville has assumed more definite shape, and as the project is in the hands of experienced zinc smelters it is receiving more serious attention than has been given to previous proposals. Messrs. Augustine and Jones, formerly associated with the American Metal Company's zinc smelters at Collinsville and Bartlesville, Okla., have visited Leadville on a trip of inspection of the mines. It is reported that they have contracted for the ore supply from at least one mine, and have investigated possible sites for their plant. They propose to produce zinc oxide from low-grade carbonate of zinc, but the details of their process have not been announced. The commercial phase of the matter is all-important, and probably has received the careful attention of the promoters. If the plan is carried out the plant will be erected this summer and be in operation by fall.

Prospects are again bright for the unwatering of some of Leadville's older mines, particularly the downtown district. A new scheme is being promoted by ex-Governor Jesse F. McDonald, who is securing long-time leases on mines in the vicinity of the Penrose shaft, with the intention of pumping water at that point.

### Organizations of Mining Men

Colorado and Utah mining men have organized for the purpose of securing for the mining industry the recogniation which they feel is due to the leading industry of those states. The meetings, which were held in Salt Lake City and Denver, occurred too late to be reported in this issue. It is a regretable fact that mining men have not stood together in matters relating to their industry, with the result that legislatures have passed inane laws vitally affecting mining in an adverse way. One particularly flagrant sample of this is the mine taxation law passed by Colorado's last legislature, without so much as a serious protest on the part of mining men. Their attention was called to the bill, but they regarded it as too outrageous to be considered seriously. Apparently, however, nothing is too foolish or unfair to get past some of our legislative bodies if there is no concerted protest. Mining men have only themselves to blame if they do not unite to create a strong sentiment in favor of a fair recognition of their industry, and it is hoped that something good will come out of these efforts in Utah and Colorado.

### Prospecting for Carnotite

The proposed action of the federal government in withdrawing carnotite deposits from private exploitation has resulted in a rush of prospectors to the districts where these ores have been found, also in the "discovery" of several new districts. A great deal of this feverish excitement has been created and fostered by the daily papers, which have printed the most absurd statements regarding the value of the ore and the extent of the deposits. Thus, for example, one district is said to contain "100,000,000 pounds of radium ore which will make between 100 and 150 ounces of radium, worth more than $900,000,000." The Colorado deposits, we are informed, are low-grade, and consequently are converted into "pitchblende ingots" before shipping East. With such glittering prospects held before the uninitiated, it is not surprising that they have been induced to search for this newest El Dorado. That they will return rich in experience and with a dubious regard for radium is a foregone conclusion.

The production of uranium, vanadium and radium in 1913 has been reported by F. L. Hess, of the Geological Survey. Fifty tons of pitchblende containing 1.49 per cent $U_3O$ was shipped from the Kirk mine in Gilpin county, Colorado. The Belcher and Calhoun mines in the same district sold only a few pounds of the same mineral. The shipments of uranium and vanadium were equivalent to 38 tons of $U_3O$, and 914 tons of $V_2O$. These quantities are equivalent to 32.3 tons metallic uranium and 412 tons metallic vanadium. The recoverable radium from the uranium ores is estimated at 9.79 grams of metal, worth $120 per milligram, or a total value of $1,055,000. The value of the carnotite ores sold was about $142,000, which represents the uranium value only, as little or nothing was paid for vanadium. The production for 1913 was the largest yet made.

### Copper Hydrometallurgy

Among the companies now investigationg the hydrometallurgy of low-grade copper ores is the Nevada-Douglas, owning mines in Nevada. Tests have been under way in Denver at the plant of John E. Greenawalt, and while the work is not yet completed the results are very encouraging. The company has recently made public the statement that the cost of electrolytic precipitation is 1.38 cents per pound of copper, and gives an estimate of 8 cents per pound as the probable total cost of producing copper, including mining, treatment and freight charges. The Greenawalt cell differs from others in having the electrodes arranged horizontally instead of vertically, with only one anode and cathode in each shallow vat, the anode being uppermost and only slightly submerged. The solutions are saturated with sulphur dioxide prior to electrolysis.

### The Bureau of Mines and Utah

About a year ago Utah provided for the establishment of a metallurgical research department at the School of Mines of its State University, the purpose of the department being "to conduct experiments and researches, either alone or in cooperation with the National Bureau of Mines and other agencies, with a view to finding ways and methods of profitably treating low-grade ores, of securing a higher percentage of extraction of metals from their ores, and of obtaining other information that shall have for its object the benefit of the mining industry." Almost a year elapsed before a beginning was made to carry out the provisions of the law. Recently the Bureau of Mines sent Mr. Dorsey A. Lyon and Mr. Robert M. Keeney to Salt Lake City to start the work, and it is now under way.

### Quicksilver In Nevada

At Ione, Nev., the Nevada Cinnabar Co. has completed a modern plant for the treatment of mercury ores, and expects to commence operations this month. The company owns about 600 acres of land from which the ore will be mined by quarrying from open pits. The plant is operated throughout by electric power, and the furnace has a capacity of 50 tons daily. It is expected that ore containing 1 per cent mercury will be handled profitably.

### Company Reports

**The Portland Gold Mining Co.** reports unusually satisfactory results from its operations during 1913. The net earnings amounted to $604,443, of which $300,000 was paid in dividends. Ore mined and shipped to the remodeled mill at Colorado Springs amounted to 53,245 tons, of an average value of $25.93 per ton. The mine also produced 127,054 tons of low-grade ore, much of which was taken out in course of development. This, together with 51,108 tons of low-grade ore taken from the dump, constituted the material treated in the new Victor mill. The average assay value of this material was $2.95 per ton. Extensive development is planned this year for the seventeenth level of the mine. The Roosevelt drainage tunnel is lowering water in the mine at the rate of about 8½ feet per month, and will drain the property to a further depth of 500 feet. The Victor mill was enlarged during the year by the addition of an ore-bin, Chilean mill and eight concentrating tables. The report does not contain as complete data as usual on metallurgical operations.

From the quarterly reports of the **Nevada Consolidated, Chino and Utah** copper companies for the fourth quarter of 1913, the following data are tabulated:

| | Nevada Con. | Chino | Utah |
|---|---|---|---|
| Ore milled, tons..... | 833,989 | 429,750 | 2,113,080 |
| Per cent copper..... | 1.58 | 2.08 | 1.22 |
| Copper produced, lb. | 16,684,955 | 12,021,872 | 23,884,467 |
| Cost copper per lb., c. | 8.63 | 9.17 | 8.93 |
| Extraction, per cent. | .... | 65.54 | .... |

**Camp Bird, Ltd.**, has issued a circular regarding conditions at the Santa Gertrudis mine in Mexico, in which it is stated that while the internal conditions in Mexico have not as yet affected the company's operations, it is deemed advisable to pass the half-yearly interim dividend in order to be able to meet any unforeseen contingencies.

The earnings have been ample to meet the dividend as usual, but it is deemed prudent not to disburse the same.

# Mechanical Refrigeration—II

## The Compression Refrigeration Cycle

BY H. J. MACINTIRE

The compression refrigeration cycle will not appear complicated if the essential duty of the machine is held in mind. It should be understood first that vapors only are used as refrigerating mediums and more particularly ammonia and carbon dioxide. These vapors are made to condense and form a liquid by being compressed sufficiently to allow of condensation with the cooling water present. The condensing pressure varies directly with the temperature of the cooling water, though the ratio is different for each vapor. Cooling water is absolutely essential and the cooler this water the more readily the vapor can be condensed.

Refrigeration is obtained by allowing the liquid refrigerant to abstract heat from its surroundings—the pressure under which the vapor does this being arranged as desired. The boiling temperatures of water under one atmospheric pressure is 212° Fahr., but under 150 lb. gage pressure it is about 365.6° Fahr. In like manner the temperature under which ammonia boils when its pressure is one atmosphere is — 26.8° Fahr., but at 15 lb. gage the boiling temperature becomes — 0.8° Fahr. Refrigeration, as we understand it, is simply the removal of heat at a temperature below that of the atmosphere. If a body is colder than the surroundings, heat flows from these surroundings to the cold body. Refrigeration may require, then, either the lowering of the temperature of a body below the atmospheric temperature or the maintaining of this low temperature.

In other words, the liquid refrigerant is allowed, then, to boil at such a pressure as will give the required temperature to the refrigerated object. This pressure is under the control of the engineer, by proper adjustment of the speed of the compressor and of the liquid refrigerant passing into the cooling coils.

### THE REFRIGERATING CYCLE

Because an expensive refrigerant (or working fluid) is used—usually ammonia or carbon dioxide, as just mentioned—the refrigerating cycle is a closed one, and the fluid is used continuously. The cycle of operations, being composed of heat exchanges, can best be represented by a heat diagram as shown in Fig. 1. The ordinates are temperatures in degrees Fahrenheit absolute (zero ordinate being the absolute zero) and the abscissa are so chosen that an area on the diagram represents heat units in B.t.u.

The point 2 corresponds to the admittance of the liquid to the refrigerating coils. The pressure on the liquid had been that of the condenser, and in the cooling coils it is the so-called back pressure—an amount considerably lower. Point 2, then, corresponds to the expansion valve of the refrigerating cycle. During the drop of pressure the temperature has to decrease also according to the physical laws just mentioned. The only way in which this decrease of temperature is possible is to have a part of the liquid evaporated.

In the diagram 120 is a line representing the condition of the liquid, whereas *7P* corresponds to that of a dry saturated vapor. The region between these two lines represents the condition of saturation. Evidently, then, a pound of the liquid refrigerant may be represented by some point as 1 on the liquid line. If heat is added and evaporation begins, heat will be supplied at constant temperature until all the substance is evaporated, and the process may be represented by the point moving from 1 to 7. The heat added (called the latent heat of vaporization) is found to be equal to the area below the line 17. Likewise the region to the right of *7P* is that of superheat—an intermediate condition between that of saturation and of a perfect gas.

As the liquid passes the expansion valve at 2, then, it enters a condition of lower pressure and lower temperature, and a certain amount of the liquid, some 5 per cent to 15 per cent, is evaporated in order to lower the temperature of the remainder. Subsequent evaporation in the cooler is at $t_3$ and is equal in heat units to the area under the line *3P;* that is, the area *3PS8* is equal to the heat added (refrigerating effect) by the goods.

### WET COMPRESSION

As refrigeration progresses the liquid is changed into a saturated or slightly superheated vapor which must again be returned to the condition of a liquid. The compressor serves this purpose. The remainder of the cycle, however, depends on the details of the compression as far as the capacity of the installation and the efficiency of operation are concerned. The wet compression—so-called—permits a small amount of liquid ammonia to pass into the cylinder of the compressor with the vapor. During compression the temperature of the vapor begins to rise, a tendency which is partly neutralized by the liquid injection, the latter absorbing heat by evaporation similar to the action of water in the old-style wet compression for compressed air machinery. If a large amount of ammonia is admitted the compression stroke may be represented theoretically by the line 47, but the usual wet-compression line is shown by 56, giving some 40 deg. of superheat at the point 6.

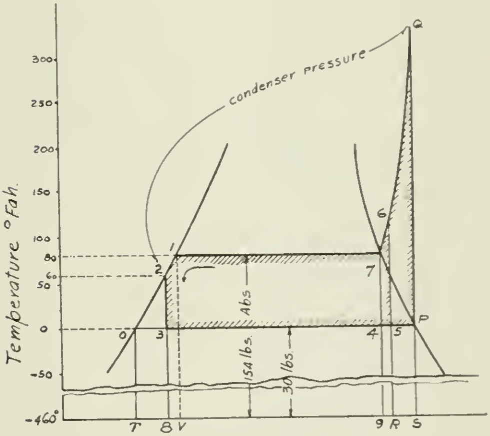


FIG. 1—REFRIGERATING CYCLE

### DRY COMPRESSION

Another, and by far the more common method of operation, is to allow dry or slightly superheated vapor to enter the cylinder, which in this case is water-jacketed. The temperature at the end of compression is quite great, often 300 deg. Fahr. to 350 deg. Fahr., but full refrigerating effect is obtained from the ammonia, giving in Fig. 1 a theoretical advantage over the wet compression of 11 per cent and 8 per cent respectively. There are other operating factors which give decided advantages to the dry-compression cycle, such as greater volumetric efficiency, greater allowable piston speed, etc.

The compressed vapor is now exhausted into coils in metal contact with water. The water cools the refrigerant to approximately its own temperature during which time the heat due to the superheat *Q*79*S*, the heat of condensation 71*V*9, and part of the heat of the liquid 128*V*, are abstracted, thus bringing the substance back to 2, which was the point given as the beginning of the cycle. The refrigerating cycle, then, consists of a drop of pressure at the expansion valve, the evaporation at the refrigerating temperature, the compression, and finally the condensation at the upper pressure.

### INDICATOR CARD

Let us consider the cycle from another standpoint—that of the work performed per compressor stroke. If we plot the pressures in the cylinder for various positions of the piston, the indicator diagram shown in Fig. 2 is obtained. Here, in contradiction to Fig. 1, the area of the enclosed figure is the work done by the piston on the vapor, and this is proportional to the total power supplied. It is usually important to keep this supplied power down to a minimum, and to do so certain things, as with air compressors, must be avoided. These are wire drawing through the suction valve, excessive resistance to the vapor passage through the discharge valves, the valve ports and discharge pipes, and finally in the obtaining of as flat a compressor curve *ac* as is possible.

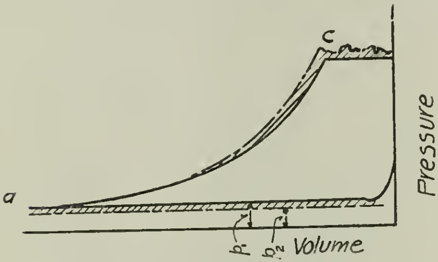


FIG. 2—INDICATOR DIAGRAM

The compression curve has been given considerable attention and the compressors using oil or ammonia injection as a rule have a flatter curve than those using the water jacket only. The tendency at present, however, is to increase the piston speed; this fact alone would cause the former method to be abandoned as it was for air compressors twenty or thirty years ago. Although a maximum pressure of from 200 to 225 pounds is frequently obtained during compression, yet multi-stage compression for refrigeration is not used because of mechanical difficulties and the decided variation of the discharge pressure with change in the temperature and the quantity of the condensing water.

The shaded areas at the top and the bottom of the indicator card may be decreased by care in the design of the valves. Mechanically operated valves have not yet been used, even for the inlet stroke. The desirable net area of the inlet valve depends on the piston speed, and should be from 4 to 8 per cent of the piston area. In air compressors and blowing engines the suction valves frequently have from 14 to 20 per cent of the piston area, but these high values are for high piston speeds, much above the present refrigerating practice. The pressure $p_1$ corresponding to the suction pressure in the compressor should not be much greater than $p_2$ corresponding to the cooler pressure. Differences of pressure much over one pound should be investigated critically, likewise the maximum compressor pressure should not be much greater than the condenser pressure for the same reason.

### CONDENSER PRESSURE

The condenser pressure depends directly on the temperature and the amount of the cooling water. Without cooling water refrigeration is practically impossible. As is seen in Fig. 2, the work of compression increases with an increase of condenser pressure, which is a little less than the discharge pressure from the compressor. It is, therefore, very desirable to use as cool condensing water as is possible, especially where use is made of motor-driven compressors.

Table I, which is the result of considerable experimentation, is taken from the Proceedings of the American Society of Refrigerating Engineers, 1906. In this table it is seen that one gallon of water per ton of refrigeration (a refrigerating effect equivalent to the abstraction of 200 B.t.u. per minute) at 60° is nearly equivalent to 1½ gallons at 70°, two gallons at 75° or three gallons at 80° F. As electric motor-driven compressors are becoming increasingly popular, the desirability of cool condensing water is very apparent.

TABLE I. AMOUNTS OF COOLING WATER

*Table I—Amount of Cooling Water*

| Initial Temperature of Cooling Water. | Gallons of Water per Minute, per Ton. | | | | | |
|---|---|---|---|---|---|---|
| | ½ | ¾ | 1 | 1½ | 2 | 3 |
| 50° F | 226 | 163 | 137 | 114 | ... | ... |
| 55 | 245 | 178 | 150 | 126 | ... | ... |
| 60 | ... | 195 | 165 | 139 | 127 | ... |
| 65 | ... | 212 | 181 | 152 | 140 | ... |
| 70 | ... | 231 | 197 | 167 | 153 | 140 |
| 75 | ... | ... | 215 | 183 | 168 | 154 |
| 80 | ... | ... | 234 | 199 | 184 | 169 |
| 85 | ... | ... | ... | 217 | 201 | 185 |
| 90 | ... | ... | ... | 236 | 218 | 202 |
| Range | 56 | 37 | 28 | 18.7 | 14 | 9.3 |

Liquid Refrigerant at Expansion Valve = 68° F.

Figures in table are condensing pressure in pounds per square inch gage.

The suction pressure, as already mentioned, is at the command of the operator and should be governed by the work to be performed. For instance, if air cooling down to 50° F. is desired, the boiling temperature of the refrigerant should be about 20 to 30° F. and not 0° or lower. The reason for this is to be found on the consideration of the specific volume at these temperatures. The volume of one pound of ammonia at 30° is 4.82 cubic feet, and at 0° it is 9.19 cubic feet or an increase of necessary displacement of the compressor (in work done and in capacity as well) of a little over 90 per cent. An advantage, however, is obtained in using the lower boiling temperature as far as the condenser is concerned, as the greater temperature difference on the two sides of the condenser pipes will allow a smaller area of condenser. The great increase in operating cost is apparent from what proceeds, however.

University of Washington,
Seattle, Wash.

---

**Tungsten ores were produced** by six western states in 1913—Colorado, California, Idaho, Arizona, South Dakota and Nevada. Boulder county, Colorado, was the largest producer, with an estimated output of 953 tons of ferberite. The total production for the United States was equivalent to 1525 tons of ore, carrying 60 per cent tungstic acid, $WO_3$. The Atolia district, California, was the second largest producer, and was the first in rank of scheelite producers. Prices generally ranged from $6 to $7.50 per unit of 20 lb. of $WO_3$, and were higher than in 1912.

**Concentration tests on Mesabi iron ores** have been made at the experiment station of the Minnesota School of Mines, and reported in Bulletin No. 2. A wide variation in grade of concentrates from crude ores of practically the same grade seems to indicate that the texture and character of the several sizes of material composing the crude ore are the criterion of washability, and not their chemical analysis.

# The Manufacture and Uses of Blaugas

BY DR. HUGO LIEBER

William Murdoch's invention in 1792 of a process for the manufacture of an illuminating gas, and the first establishment of a commercial gas plant in Birmingham ten years later was destined to be rapidly developed and perfected, so that it soon became a commercial necessity. However, one of the disadvantages of this invention was the fact that it required a considerable investment of capital for the manufacturing plant and its maintenance, and especially for the equipment of gas mains required to conduct the gas to the consumer. Therefore, it was soon recognized that a gas factory could be commercially and successfully operated only in such districts which were thickly populated, and where a large number of customers could be connected with the gas mains and thus be made consumers of this commodity.

The great advantages derived from the use of gas were soon recognized and created a considerable demand for same, but owing to the limitations of a supply of gas to the territory traversed by the gas mains, and as beyond reach of these there was soon created a great and constantly growing demand for this commodity, many attempts were made to fill this demand.

These experiments resulted in various inventions of more or less value, having for their object the production of a compressed or condensed gas in such form that it would be commercially transportable beyond the reach of the gas mains.

In the experiments conducted by various investigators, coal gas as well as oil gas was used, but attempts to produce a commercially condensed and transportable coal gas were soon abandoned in favor of oil gas on account of the higher calorific value of the latter. The compressed oil gas is to-day still used very extensively, especially for lighting of railroads, buoys, lighthouses, etc.

The compressing and commercially adopting of such compressed oil gas was successfully done especially by Pintsch, and with such compressed oil gas is usually identified the name of Pintsch owing to the great introduction of the Pintsch system throughout the world, and such compressed oil gas is usually known as Pintsch gas.

Under the Pintsch system the oil is distilled at fairly high temperatures (900 deg. to 1000 deg. C.) so as to produce as large an amount of fixed gases as possible. These fixed gases are subjected to a pressure ranging from 5 to 16 atmospheres, in the United States 6 atmospheres being the prevailing pressure. As under the Pintsch system, after distillation and compression certain of the hydro-carbons are liquefied, these have to be removed, and only the remaining gaseous compressed hydro-carbons are permitted to enter the shipping containers.

A German chemist, Herman Blau, succeeded in making a great improvement in the production of a transportable compressed oil gas. He compressed oil gas to such a degree that the bulk of same was liquefied. The process employed by Blau is in brief as follows:

In the original process gas oil is conducted into the retorts the same as in the manufacture of Pintsch or other oil gas, and is vaporized and decomposed in these retorts under a temperature of about 550 deg. C. to 600 deg. C. This low temperature is employed in order to prevent the production of a large percentage of fixed gases, as contrary to the heretofore existing principle it was the desire of Blau to produce as large a quantity of the coercible hydro-carbons and as small a quantity of the permanent gases as possible. After the oil has thus been distilled, the gas obtained is conducted in the usual manner through hydraulic mains, coolers, cleaners and scrubbers in order to remove the tar which these gases contain. After this the gas is purified of its chemical impurities by being forced through chemical cleansing agents, where especially sulphide of hydrogen and carbon dioxide, etc., are removed. This being completed, the gas is conducted in the usual manner into large gas holders for storage purposes. With the exception of the difference in the temperatures employed in the distillation process, the Blau process up to this point does not vary materially from any of the other well-known processes of oil gas distillation employed heretofore.

Since its first introduction, the Blau process has been very materially and rapidly improved from time to time, these improvements having for their object the production of a better quality or a drier gas, and also the greater yield from a certain quantity of oil. In the original process as employed by Blau, the gas from the holder was drawn into a cooler where, under a suitable process, it was cooled considerably below zero in order to liquefy and discard at this stage certain of the coercible hydro-carbons which, in the finished product, were not desired; that is, such hydro-carbons which under normal pressure and temperature would again liquefy.

Under the new process as it is employed in the various Blaugas factories at the present time, this preliminary cooling has been discarded. The gas is drawn directly from the holder into the compressor which is usually a three-stage or four-stage compressor. The liquefying and discarding of those coercible hydrocarbons which are not desired in the final product now takes place in the first and second stage of the compressor, and the balance of the gas passes on into the third and eventually the fourth stage where the gas is compressed up to 100 atmospheres. During all stages of the compression water is injected into the compressing chambers for lubricating and cooling purposes. The water which is carried over after the final compression is separated from the liquefied hydrocarbons after the last stage of compression, and is then withdrawn from these by a suitable device. The refuse tar obtained from the cooled and scrubbed gases is collected in proper receptacles, and from there is pumped into tanks from where it flows by its own gravity to the retorts where, with compressed air or steam, it is sprayed under the retorts, and is thus used to supply all the heat required for these retorts.

As in the course of the manufacture and during the distillation of the oil a certain amount of permanent gases have been produced which the liquefied hydrocarbons have been unable to absorb, these permanent gases are conducted into large cylinders from which, by means of proper reducing and regulating valves, they are conducted into the engine where they produce all the power which is needed in a Blaugas plant.

The whole Blaugas process, as it is now employed, is so minutely worked out that but a very slight excess of tar and permanent gases is obtained beyond the quantities required for heating and power purposes. The final product consisting of liquefied hydro-carbons, and absorbed therein or dissolved thereby non-liquefied hydro-carbons, is of such composition that this whole aggregate will remain a liquid as long as same is under the pressure employed in the process, but these liquefied hydro-carbons will at once become converted into a gaseous aggregate if the pressure is reduced to approximately atmospheric pressure. These liquefied hydro-carbons are conducted into suitable steel cylinders or bottles for transportation purposes.

Under the compression of 100 atmospheres the oil gas is reduced to 1/400 of its volume, the gas so obtained being of a specific gravity which is approximately the same as atmospheric air. One ltr., that is, 1.246 gr. of Blaugas at 0 deg. C. and 760 mm barometer contains 1.042 gr. carbon and 0.204 gr. hydrogen. This gas has a calorific value of about 1800 B.t.u. per cu. ft., or approximately three times the heat value of ordinary city gas.

The explosive range of Blaugas is lower than that of any other commercial illuminating gas, which the following table will show:

| | FROM | TO | EXPLOSIVE RANGE |
|---|---|---|---|
| COAL GAS.... | 6.33% gas<br>93.67% air | 19.33% gas<br>80.67% air | 13% |
| ACETYLENE. | 2% gas<br>98% air | 49% gas<br>51% air | 47% |
| HYDROGEN.. | 9.5% gas<br>90.5% air | 66.3% gas<br>33.7% air | 56.8% |
| BLAUGAS..... | 4% gas<br>96% air | 8% gas<br>92% air | 4% |

As has been stated before, the heat value per cubic foot of Blaugas is about 1800 B.t.u., whereas that of acetylene is 1500 B.t.u. per cubic foot and of hydrogen 425 B.t.u. per cubic foot. As the volume of Blaugas is reduced to 1/400 under its compression, it requires much smaller receptacles to transport a certain number of heat units with Blaugas than with any other gas.

Of the commercially transportable gases are to be considered acetylene, hydrogen and Blaugas, as Pintsch gas is a transportable gas in a limited sense only. Acetylene can be considered as a transportable gas only under the so-called "Acetylene Dissous" system. The following table will show the heat value per cubic foot, the container capacity, the weight of containers required for a given number of heat units, the number of containers required, and the price per 100,000 B.t.u.:

| | HYDROGEN | ACETYLENE DISSOUS | BLAUGAS |
|---|---|---|---|
| Heat value, per cu. ft.... | 425 B.T.U. | 1500 B.T.U. | 1800 B.T.U. |
| Contents of a container of 1 cu. ft. water capacity | 120 cu. ft. | 100 cu. ft. | 300 cu. ft. |
| Weight of containers required to transport a given quantity of heat units (for example 540,000 B.T.U.) ....... | 1060 pounds | 432 pounds | 100 pounds |
| Number of containers required to ship 5,100,000 B.T.U. ................ | 106 | 36 | 10 |
| Price for 100,000 B.T.U.. | $1.41 | $1.00 | 44c. |

Hydrogen per cu ft., 3/5c.
Acetylene Dissous per cu. ft., 1½c.
Blaugas, per cu. ft., 4/5c.

Blaugas is transported in steel cylinders of various dimensions ranging in size (water capacity contents) of from ¼ ltr. to about 100 ltrs. The size mostly used is a cylinder with a water capacity of about 27 ltrs., or about 1 cu. ft. This cylinder when properly filled contains about 20 lb. of Blaugas, which will become converted into about 250 cu. ft. of expanded gas when the pressure is released. As Blaugas contains no carbon monoxide it is a non-poisonous gas.

Blaugas is used mostly in such districts where no gas is supplied from a central gas plant through ordinary mains, but it is also used very extensively in districts where city gas is supplied, especially for steel and cast-iron welding and cutting, brazing, soldering, for laboratories and such purposes where a uniform gas with high heat units is essential.

In districts where gas is not supplied through mains or through a central plant, Blaugas is used for all purposes where otherwise city gas is used, namely, for illuminating, cooking, ironing, heating, and similar purposes.

The cylinders are attached by means of a reducing valve to a small expansion tank, and from there the gas is conducted into the pipe line by a pressure regulator. As Blaugas is under a high pressure when delivered to the consumer, it is a very simple matter to produce so-called pressure gas wherever same is required, pressure gas being very desirable for the production of brilliant illumination, one c.b.f. of Blaugas producing 80 candles in an incandescent Welsbach burner.

The first Blaugas factory was erected in Augsburg, Germany. This was rapidly followed by other factories in Budapest, Copenhagen, Bucharest, St. Petersburg, and Hoek von Holland. In the United States at the present time there are factories in Long Island City, St. Paul, Kansas City, Omaha, and Portland, Me. There are a number of factories now in course of construction.

## Notes on the Gran-Annular Electrical Furnace

BY ZAY JEFFRIES

This is the name which has been given to the electric furnace invented by C. H. Fulton and W. A. Coursen. The name implies "granular" because the electric resistor is in the form of grains and "annular" because the grains occupy a space in the furnace the shape of a hollow cylinder. The furnace was described in 1912 by C. H. Fulton in connection with the investigation of slag.[1] Since then a few mechanical improvements have been made and considerable work has been done to ascertain the most suitable kind and size of resistor to use.

### Description of Furnace

Fig. 1 shows the Gran-Annular electric furnace in cross-section. The essential features are given by the inventors as follows: (1) Two concentric cylindrical tubes, the inner one of which forms the heating-chamber, made either of magnesia or alundum, and the cylindrical space between which, when filled with a granular resistor, becomes the resistor cylinder. (2) A resistor of uniform cross-section throughout its length. (3) The positive and firm insertion of the tubes in the electrode plates, thus maintaining the resistor chamber in perfect shape. (4) That any part can be readily and cheaply replaced. (5) Simplicity and compactness of construction, preventing racking and distortion during heating.

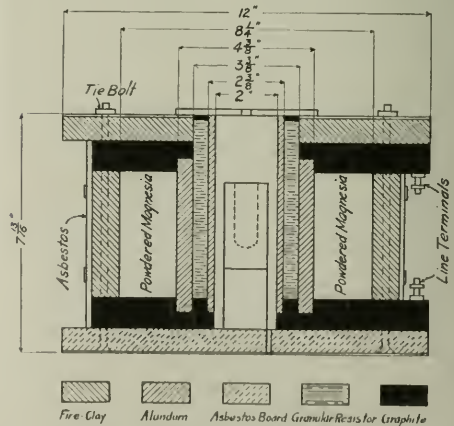


FIG. 1—CROSS-SECTION OF THE GRAN-ANNULAR ELECTRIC FURNACE

A furnace with the dimensions given satisfies most of the laboratory requirements.

---

[1] Transactions American Institute of Mining Engineers, Vol. XLIV.

### Resistors

Three materials are at present available, kryptol, granular carbon, such as is furnished by the National Carbon Company, and granular graphite, furnished by the Acheson Graphite Company. The curves in Fig. 2 show the variation in the specific resistivities of the three materials per cubic inch, with change in temperature. The furnace was used for the determinations. In each case the resistor was put into the furnace loose, i.e., with pressure due only to its own weight.

The hot junction of a platinum platinum-rhodium thermo-couple, protected by a quartz tube, was placed in the resistor, a distance from the top electrode equal to one-fourth the distance between the electrodes. The resistances were obtained by measuring the current and drop in potential between the electrodes.

Temperature and resistance readings were taken at the same time in fifteen-minute intervals. The temperature indicated by the thermo-couple is taken as the average of the resistor. That the average temperature was somewhat lower than the results given is highly probable for reasons that will appear later. The radiation of heat, however, is more active at the top electrode than at the bottom, a condition which tends to correct the error.

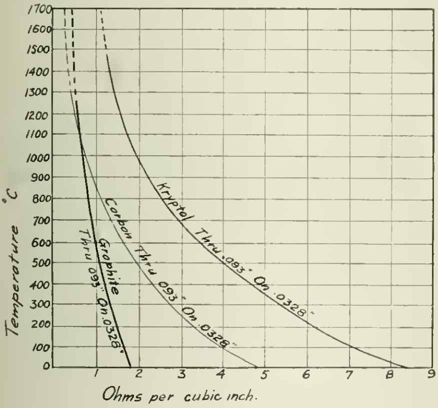


FIG. 2—TEMPERATURE, RESISTIVITY CURVES FOR KRYPTOL, CARBON AND GRAPHITE

One thing common to all of the materials is the marked negative coefficient of resistivity. The writer offers an explanation for this which fits the facts in the case very closely.[2] A discussion of the theory is especially invited. In the first place, Acheson graphite has a much more constant resistance than is indicated by the curve.[3] The decrease in resistivity must then be due to an increase in contact area between the grains. This is brought about by the expansion of the grains with increase in temperature, wedging preventing the displacement of the resistor mass as a whole, and thus decreasing the resistance. This may be compared to a carbon plate rheostat, the expansion of the grains being analagous to increasing the pressure between the plates with a hand wheel.

Considering, then, that the decrease in resistivity of graphite is almost entirely due to the better contacts between grains, why do kryptol and carbon show larger decreases? Kryptol is a mixture of carbon and some dilutent which is probably not a good conductor of electricity and also probably contains some graphite. Carbon itself has a marked negative coefficient of resistivity, which, in conjunction with the better contacts, makes the negative coefficient of kryptol much greater than graphite. With this theory in mind it would seem that carbon alone would have a greater negative coefficient than kryptol. That this is true is shown by an example taken from the curves.

| | Graphite | Kryptol | Carbon |
|---|---|---|---|
| 0 degrees C.......... | 1.80 ohms | 8.30 ohms | 4.80 ohms |
| 1200 degrees C.......... | 0.60 ohms | 1.60 ohms | 0.50 ohms |
| Ratio .................. | 3 : 1 | 5.18 : 1 | 9.6 : 1 |

At high temperatures in the presence of oxygen there is a condition which tends to increase the resistance. The contact points of the grains being the hottest will oxidize more readily than the cooler parts, and as wedging prevents the free settling of the grains by gravity, some of the contacts will have their areas reduced and others may be burnt out completely. With an excess of oxygen and at a very high temperature, this condition may overcome the negative coefficient and actually indicate an increase in resistance with an increase in temperature. This increase must be due to the reasons given because on cooling, the resistance increases further.

### Comparison with the Platinum Wire Furnace

When compared with the platinum wire furnace the gran-annular furnace has two unquestioned advantages. (1) The cost is less than one-third as much, and (2) it can be used safely at temperatures 300 degrees C. higher than the platinum wire furnace. The current control, however, is better in the platinum furnace because the resistance is the same no matter how many times the furnace has been heated. The resistance of the gran-annular furnace increases slightly every time it is heated above 1200 degrees C. This is caused by air gaining access to the resistor through the pores of the inside alundum tube, when the furnace is opened, and oxidizing some of the carbon.

When the resistance gets so high that a short circuit through the furnace does not give as high a temperature as is desired, the resistor is poured out and the furnace is refilled with the same material. A similar result can be obtained by packing the resistor, but since unequal packing causes hotspots, the former method is used. One filling usually lasts from forty to fifty heats to a temperature of 1500 degrees C. It takes about five minutes to change the resistor. Although the resistance changes from heat to heat, during any given heat the current can be controlled within very narrow limits.

The fact that granular resistors have negative coefficients of resistivity gives the gran-annular furnace two distinct advantages over wirewound furnaces. In both types the hottest part of the heating chamber is somewhere near the middle as a result of the greater heat radiation at the ends.[4] In the wire type, since the resistance of the wire is the greatest where the temperature is the highest, more calories of heat will be liberated per unit of length in the middle of the furnace than in any other part. Therefore, the most heat is liberated where it is least desired, thus increasing the difference in temperature between the middle and adjacent parts.

In the gran-annular furnace the hottest part has the least resistance and hence less heat is generated in the middle than at any other part of the heating chamber. In fact, there is an absolutely automatic adjustment tending to make the temperature uniform throughout the entire length of the resistor column.

The other advantage is the automatic regulation in starting the furnace. A furnace should be heated in about equal temperature intervals. A given number of watts will raise the temperature of a cold furnace several times as many degrees as will an increase of the same number of watts 1000 or 1200 degrees higher. The wattage should be progressively increased while heating. A wire furnace has its least resistance when cold and demands changing the external resistance while heating. The gran-annular furnace, having its greatest resistance when cold, can be started with a given external resistance (which will be considerably less than the resistance of the furnace) and as the temperature increases the wattage increases, due to the furnace resistance approaching the external resistance.

---

[2] Read Electrochemical and Metallurgical Industry, Vol. I, pp. 481-482.

[3] Northrup, Metallurgical and Chemical Engineering, May, 1913.

[4] Electric Furnaces in the Iron and Steel Industry, Vom Baur, page 86.

### Operation and Control of Temperature

The furnace can be used with either direct or alternating current. Where the latter is available any of the above-named resistors can be used, carbon and graphite demanding lower voltages than kryptol. A furnace having dimensions as given in Fig. 1 requires a pressure of 110 to 115 volts when kryptol is used. Since nearly all laboratories have alternating or direct current at this pressure, the use of lower voltages will not be discussed further. When direct current is used the Weston miniature precision ammeters and voltmeters are entirely satisfactory for watt measurements.

For the proper control of temperature, C. H. Fulton and the writer have designed a special rheostat. It consists of nineteen coils of resistance wire, each of which is connected to a separate single-throw switch. The first coil has a resistance of 6 ohms and a carrying capacity of 18 amperes, the reason for which will appear later. The second coil has a resistance (102 ohms) such that when connected in parallel with the first coil, their combined resistance is 5 2/3 ohms.

In this way the addition of each coil in parallel lowers the resistance 1/3 ohm, and adds as much carrying capacity as will result from the decreased resistance, until 1 ohm is reached, when each additional coil decreases the resistance ¼ ohm. Thus, when all of the coils are used at the same time, they have a resistance of ¼ ohm and a carrying capacity of 50 amperes.

A 50-amp. single-throw switch, used for short-circuiting the furnace, is also provided on the same switchboard. A current of 50 amperes is seldom needed, so the excess carrying capacity permits the cutting out of some of the intermediate coils to obtain small differences in resistance. For instance, when the first thirteen coils are in, the resistance is 2 ohms. The actual resistance of the second coil is 102 ohms and by disconnecting it the resistance of the twelve remaining coils becomes 2.04 ohms. Now, if the third coil, having a resistance of 91 ohms, be disconnected, the resistance of the remaining coils becomes 2.09 ohms.

In operating both granular-resistor and wire furnaces and in designing rheostats for same, this fact should be taken into consideration: that with a given external resistance, the watts consumed in the furnace becomes a maximum when its resistance is equal to the external resistance. If a furnace has a resistance, when cold, of 6 ohms and an external resistance of 4 ohms be used and the pressure is 110 volts, there will be 726 watts consumed in the furnace. As the temperature of the resistor increases its resistance decreases quite rapidly so that when the resistance of the furnace reaches 4 ohms it is receiving 757 watts, decreasing to 740 watts when a furnace resistance of 3 ohms is reached.

In taking critical points with a thermo-couple under these conditions a slight change in the heating rate may be noticed when the furnace resistance just equals the external resistance, which is due to the furnace and not to the sample under investigation. If current is used when cooling another point shows itself. These points, however, are only detectable when a potentiometer is used to measure the voltage of the thermo-couple.

The maximum resistance of the rheostat is obtained as follows: Having decided that 500 watts will be the minimum required (see Fig. 3) at any time, and remembering that the most unfavorable condition for a minimum, i.e., the most favorable for a maximum, is when the furnace resistance equals the external resistance, we assume this condition and solve for the latter. Let R equal the resistance sought and assume the voltage as 110. Then

$$\frac{110}{2\text{ R}} = \text{Current flowing,}$$

and

$$\left(\frac{110}{2\text{ R}}\right)^2 \text{R} = 500 \text{ watts.}$$

Whence R = 6.05 ohms.

When using the maximum resistance of the rheostat (6 ohms), we find that 504 watts is the most that the furnace can possibly receive.

### Uses

The atmosphere of the furnace above 1200 degrees C. analyzes as follows: Oxygen, 0.20%; nitrogen, 68.90%; carbon dioxide, 0.70%, and carbon monoxide, 30.20%. If a different atmosphere is desired, gas may be admitted through a hole leading from the bottom of the furnace into the heating chamber. If an oxidizing atmosphere is desired all that is necessary is to leave the hole open and provide an opening at the top of the furnace and a strong current of air flows through the heating chamber.

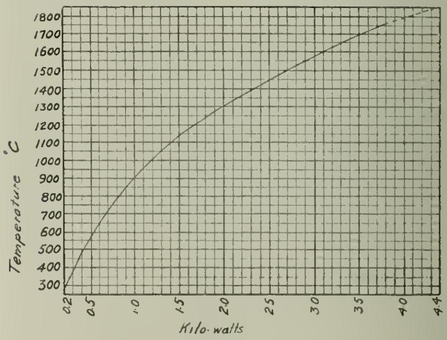


FIG. 3—KILOWATT-TEMPERATURE CURVE FOR GRAN-ANNULAR FURNACE

C. H. Fulton uses a gran-annular furnace, among other things, to make seger cone melting point determinations. The cones can be watched through a hole in the furnace cover, and good determinations be made at very high temperatures. His work with slags has already been mentioned.

F. A. Fahrenwald, doing research work for the National Dental Association, is using a gran-annular furnace. He uses it largely for melting metals, for the purpose of forming alloys, and the remarkable manner in which the furnace stands the severe usage deserves mention. It has been heated as many as twenty times in eight hours to a temperature of 1500 degrees C., the heating rate being so fast that that temperature was reached in less than fifteen minutes. In one instance the furnace was heated from room temperature to a white heat in eight minutes.

The writer is using one of the furnaces to find the critical points of alloys in a binary system. Some of the points are so slight that they cannot be detected unless the heating or cooling rates are very slow. By using the data given in Fig. 3 the thermal rate may be controlled as desired. For example, if the furnace is at a temperature of 1600 degrees C, and it is desired to locate accurately the position of critical points above 1400 degrees C., the wattage is set at 2300 and the cooling curve taken. The cooling takes about twenty minutes, while if the power is shut off the temperature drops to 1400 degrees C. in about one minute. If now the wattage be increased to 3100, a slow rate of heating will take place from 1400 up to 1600 degrees.

A temperature of 1800 degrees C. can be used with safety, as platinum has been melted in the furnace, in ounce lots, the Pt Pt-Rh couple having fused several minutes before the melt was removed. The maximum temperature of the walls of the heating chamber is limited to the fusing point of alundum (about 2050 degrees C.). It is hoped, however, that magnesia tubes will soon be available which will enable a temperature of about 2400 degrees C. to be reached.

Case School of Applied Science, Cleveland, Ohio.

# Concentration of Complex Sulphide Ore from the Mary Murphy Mine

BY DYKE V. KEEDY

The article under the above caption, in the January issue of METALLURGICAL AND CHEMICAL ENGINEERING, is very interesting. It occurred to the writer that it would be worth while to apply some figures to check it up. The results are rather surprising inasmuch as they vary so widely from those given as representing the recoveries effected by the preliminary jigging, tabling and vanning operations. One lot of 3989 tons was taken as a basis, assaying as follows:

| Gold | Silver | Lead | Zinc | Copper |
|---|---|---|---|---|
| 0.25 ozs. | 3.1 ozs. | 5.4% | 8.7% | 0.6% |

The recoveries are claimed to have been:

| Gold | Silver | Lead | Zinc | Copper |
|---|---|---|---|---|
| 75.9% | 50.6% | 86.7% | 58.6% | 55% |

From this lot of ore it is said there was obtained the following products assaying:

| | Wt., Tons | Gold, Ozs. | Silver, Ozs. | Lead, % | Zinc, % | Copper, % |
|---|---|---|---|---|---|---|
| Lead Concentrates...... | 138 | 2.26 | 12.4 | 48.8 | 10.8 | 0.7 |
| Zinc-Iron Middlings..... | 273 | 0.32 | 7.0 | 7.2 | 38.1 | 2.3 |
| Zinc Slime............. | 34 | 0.19 | 7.1 | 9.6 | 30.9 | 1.5 |
| Tailing............... | 3544 | 0.07 | 1.7 | 1.4 | 4.0 | 0.3 |
| | 3989 | | | | | |

On page 25 of the report it will be noted that the recoveries were calculated by deducting the metallic content of the tailings from that of the heads and counting the difference as recoveries made in the concentrating department; even so, the figures as given are slightly incorrect, the actual figures being:

| Heads, 3989 Tons Actually Contained | | Tailings, 3544 Tons Said to Contain | | Recoveries as by Difference | |
|---|---|---|---|---|---|
| Gold..... | 997.25 ozs. | Gold...... | 208.18 ozs | Gold ..... | 75.14% |
| Silver.. | 1236.59 ozs. | Silver..... | 602.48 ozs | Silver...... | 52.27% |
| Lead..... | 215.406 tons | Lead..... | 49.616 tons | Lead..... | 76.96% |
| Zinc..... | 347.013 tons | Zinc...... | 141.760 tons | Zinc . | 59.16% |
| Copper . | 23.934 tons | Copper.. . | 10.632 tons | Copper . | 55.57% |

These figures check pretty closely with those given in the report, except in the lead, but they should check exactly since they were presumably arrived at from the same starting point and by the same method of calculating.

This method of calculating recoveries is incorrect and misleading because of the very important fact that the large quantity of water used on the jiggs and tables and running to waste therefrom carries unseen and frequently unnoticed an unknown quantity of mineral values.

Rarely, if ever, are there any practical means at hand whereby this water can be caught and its burden of mineral values accurately determined, and since it is therefore practically impossible to catch and accurately sample the tailings, the only true and dependable method to pursue is from the other end of the operations, namely, counting, as being recovered, only the values carried in the concentrates and the balance as lost.

Figuring on this basis, we calculate the recoveries and distribute the percentage of the various values in the various products as per the following tables:

GOLD

TABLE "A"

SHOWING DISTRIBUTION OF VALUES

3989 tons of ore at 0.25 oz. =997.25 oz.

| | Tons | | Assay | Content | Per cent | |
|---|---|---|---|---|---|---|
| Lead Concentrates.... | 138 | tons at | 2.26 oz. | =311.88 oz. = | 31.27% | of tota |
| Zinc-Iron Middlings... | 273 | " " | 0.32 | " = 87.36 " = | 8.76% | " " " |
| Zinc Slimes.......... | 34 | " " | 0.19 | " = 6.46 " = | .65% | " " " |
| Amalgam............. | | | | =319.70 " = | 32.08% | " " " |
| Tailings ........... | 3544 | " " | 0.076 | " =271.85 " = | 27.24% | " " " |
| | 3989 | " " | 0.25 | " =997.25 " = | 100% | " " " |

Only the gold which reported itself in the amalgam and in the carpet, 32.08 per cent, and in the lead concentrate 31.27 per cent, total 63.55 per cent, can be dependably counted as saved. A portion, possibly 65 per cent or 70 per cent, of the gold carried in the zinc-iron middlings, 8.76 per cent, and in the zinc slime, 0.65 per cent, total 9.41 per cent, may also be saved, which would then bring the ultimate gold recovery up to about 70 per cent.

SILVER

TABLE "B"

SHOWING DISTRIBUTION OF VALUES

3989 tons of ore at 3.1 Oz. =12,365.9 Oz. Silver

| | Tons | | Assay | Content | Per cent | |
|---|---|---|---|---|---|---|
| Lead Concentrates.... | 138 | tons at | 12.4 oz. | = 1711.2 oz. = | 13.84% | of tot. silv |
| Zinc-Iron Middlings... | 273 | " " | 7.0 | " = 1911.0 " = | 15.45% | " " " |
| Zinc Slimes.......... | 34 | " " | 7.1 | " = 241.4 " = | 1.95% | " " " |
| Tailings............. | 3544 | " " | 2.4 | " = 8502.3 " = | 68.76% | " " " |
| | 3989 | " " | 3.1 | " =12365.9 " = | 100% | " " " |

On the assumption that the waste waters from the jiggs, tables and vanners did not carry away any values whatever, which, of course, is not true, and provided the sampling and assaying of the tailings truly represented actual facts, then the tailings would have carried only 1.7 ozs. per ton or 48.71 per cent of the total silver. But by these calculations we find the tailings, including the losses in the wash water, actually carried 2.4 ozs., or 68,76 per cent of the total silver; less that which was caught on the amalgam plates and carpets. No weights having been given in the report respecting the quantity of silver thus recovered, makes it impossible to calculate the ultimate recovery.

LEAD

TABLE "C"

SHOWING DISTRIBUTION OF VALUES

3989 tons of ore at 5.4% =215.406 tons lead

| | Tons | | Assay | Content | Per cent | |
|---|---|---|---|---|---|---|
| Lead Concentrates.. | 138 | tons at | 48.8% | = 67.344 tons = | 31.26% | of tot. lead |
| Zinc-Iron Middlings. | 273 | " " | 7.2% | = 19.656 " = | 9.13% | " " " |
| Zinc Slime ..... | 34 | " " | 9.6% | = 3.264 " = | 1.51% | " " " |
| Tailings ...... | 3544 | " " | 3.53% | =1251.42 " = | 58.10% | " " " |
| | 3989 | " " | 5.4% | =215.406 " = | 100% | " " " |

These calculations are made from the heads and the three weighed and sampled products, only one of which, however, at this stage of the operations, is marketable; the other two are to be further treated. The sampling of the tailings, as given in the report, 1.4 per cent, is fairly to be questioned, for reasons before stated. The lead not reporting in the lead concentrates, or in products yet to be treated, must be counted as lost. It is shown that 58.10 per cent of the total lead had passed into the tailings and was lost at this stage of the operations, leaving 41.90 as a possible ultimate recovery, even if supposing that a perfect separation of the lead will be made from the zinc-iron middlings and zinc slimes. We cannot find any way to justify the claim, made in the report, of a recovery of 86.7 per cent, but rather it looks as if some figure between 35 per cent and 40 per cent would be the maximum.

### ZINC

TABLE "D"

Showing Distribution of Values

3989 tons of ore at 8.7% =347.043 tons of zinc

| | | | | | |
|---|---|---|---|---|---|
| Lead Concentrates.. | 138 | tons at 10.8% | = 14.904 tons | = 4.29% | total zinc |
| Zinc-Iron Middlings. | 273 | " " 38.1% | =104.013 " | = 29.97% | " " |
| Zinc Slimes........ | 34 | " " 30.9% | = 10.506 " | = 3.04% | " " |
| Tailings.......... | 3544 | " " 6.14% | =217.620 " | = 62.70% | " " |
| | 3989 | " " 8.7% | =347.043 " | =100% | " " |

In like manner as with the lead, these calculations are made from the heads and the three weighed and sampled products, the tailings being calculated by difference; this for the reasons as stated before. It would be obviously unfair and misleading to make calculations upon recoveries that clearly were not made. The zinc reporting in the lead concentrates is worse than lost, as its presence in that product induces a penalty. Inasmuch as 62.70 per cent of the zinc is lost in the tailings and 4.29 per cent in the lead concentrates, a total of 66.99, there remains only 33.01 per cent from which the ultimate recovery must be made by the slime tables and electrostatic machines. It looks as if the ultimate recovery will be even below 20 per cent. In any event it seems quite impossible to check up or account for the 58.6 per cent recovery as claimed in the report.

### COPPER

TABLE "E"

Showing Distribution of Values

3989 tons of ore at 0.6% =23.934 tons of copper

| | | | | | |
|---|---|---|---|---|---|
| Lead Concentrates.. | 138 | tons at 0.7% | = .966 tons | = 4.04% | total copper |
| Zinc-Iron Middlings. | 273 | " "2.3% | = 6.279 " | = 26.23% | " " |
| Zinc Slime. ....... | 34 | " "1.5% | = .510 " | = 2.13% | " " |
| Tailings.......... | 3544 | " "0.47% | =16.179 " | = 67.60% | " " |
| | 3989 | " "0.6% | =23.934 " | =100% | |

These calculations are made on the same basis as before and, of course, for the same reasons. Technically, it may be claimed that there is here shown a recovery of 32.40 per cent, inasmuch as this amount of copper reported in the so-called finished products of this department, but commercially the story is different, since the copper tenor of the lead concentrates is too low to fetch any payment therefor. The finished copper-iron products from the electrostatic machines do not run very high in copper, if on dry assay. The high tenor of zinc will induce a penalty. Were it not for the values in gold and silver these products would hardly pay to ship. At present market prices they will fetch about $20 per ton. At best there remains less than 30 per cent of the total copper, reporting in the products, subject to retreatment, from which any marketable copper product can be recovered. Upon what basis, therefore, can be made the claim of a 55 per cent recovery?

As a summary of the foregoing tables and making a comparison with the claims made in the report, wherein the Tailings are figured against the Heads and in the other case, wherein the Concentrates are figured against the Heads, we have the following:

| According to the Report | Tailings Figured Against Heads | As Herein Calculated | Concentrates Figured Against Heads |
|---|---|---|---|
| Gold Recovered | 75.9% | Gold Recovered | 72.76% |
| Silver " | 50.6% | Silver " | 31.21% |
| Lead " | 86.7% | Lead " | 41.90% |
| Zinc " | 58.6% | Zinc " | 37.30% |
| Copper " | 55.0% | Copper " | 32.40% |

We will bear in mind that these figures relate only to recoveries as meaning that we have only deducted, as losses, the values lost in the tailings. There are losses already suffered even at this stage of the operations which are just as decided losses, in fact, as those passing away in the tails, such as the Zinc reporting in the Lead Concentrates, etc. In the subsequent steps in the operations, that is, retreatment of the Zinc-Iron Middlings and Zinc slimes further losses will be suffered. The above figures representing silver recoveries will have to be modified to some extent on account of the unknown quantity of silver caught on the carpet.

### ELECTRO STATIC DEPARTMENT

Had there been given any figures with respect to the weights of the products resulting from the electrostatic machines, it would be interesting to digest them to ascertain what recoveries were made. The question naturally arises as to why they were omitted as their absence is all the more noticeable since the weights were so freely given in the grinding and rough concentrating departments. The assay figures are interesting, particularly those relating to the "Retreatment of Electro Static Middlings."

For reasons given later herein, we are justified in assuming the chemist's figures to be correct and now we are prompted to ask, from whence comes all this Gold and Silver? In the table referred to, page 26, we find a Feed said to carry .52 oz. Gold and 9.1 ozs. Silver; this is presumably split into two products, viz.: Zinc product and Iron product; one carrying .56 oz. Gold and 9.8 ozs. Silver and the other .62 oz. Gold and 9.9 ozs. Silver. It might be assumed that a certain amount of a Middlings product, could also have been made, running very low in Gold and Silver and which would account for these values being so high in the other two products, but it appears from the assay figures that but little disturbance was made with the remaining chief constituents of the feed. For instance, the Lead tenor of the feed was 8.8 per cent; that of the Zinc product 11.9 per cent and that of the Iron product 8.7 per cent. It seems therefore after careful study of the assay figures, given in this table quite impossible to account for the large increase in Gold and Silver by reason of any Middlings product also being made. It looks very much as if some one has been fooling himself, unintentionally perhaps, but fooling himself just the same.

It does not seem possible that the results as shown by the tables given in the report are the very best attainable by the electrostatic machines. These fall so very far short of those that have been obtained in the treatment of similar ores that it seems more than likely that very material improvements can and will be made as soon as the machines are properly adjusted and the operatives get better acquainted with the requirements and learn how to meet them.

If and when certain obvious improvements have been made in the crushing and grinding departments (herein later discussed), an increased quantity of feed will come to the statics and in better condition for treatment. There will also be produced a less quantity of the extremely fine grades which are more difficult for the statics to handle satisfactorily. Hence in the final results a very marked improvement will be shown.

### REGRINDING OF STATIC MIDDLINGS

In the absence of any figures respecting relative weights and having only the assays given, it is impossible for one to see any good net results coming from the operation of this "Retreatment of the Static Middlings," but on the contrary, it looks more as if the operations resulted in a net loss. The Lead seems to have tended to concentrate in the Zinc product, which of course results in a loss. The tenor of Zinc in the Zinc product was brought up only about 6.6 per cent or say from 28.2 per cent to 34.8 per cent while the Lead in this product increased from 10.2 per cent to 11.1 per cent also there was an alleged increase in the Gold and Silver. A marketable Copper-Iron product was made although it yet carried 16.4 per cent Zinc which would largely offset its copper values were it not for the values in Gold and Silver which it is alleged to contain. The net results are unknown and as yet questionable.

### MONNELL SLIMER

It seems hardly worth while to comment upon the results as shown, from the Monnell Slimer,—except to raise the question as to the purpose to be served by keeping it at work. We realize that it has set for it, by reason of the character of feed, a task that would be very difficult for any machine to perform with any degree of satisfaction. The results in this department will show marked improvements when proper changes have been made in the Grinding Department and yet greater improvements when the whole slime problem is approached from an entirely different angle.

### REGRINDING APPARATUS

The figures given on page 24, respecting the work done by the Hardinge Mills and the Tube Mill are very interesting but their value is much enhanced when they are put in the form of percentages. The assay values of the various screen products being given, it is possible to calculate the assay of the original feed as well as that of the discharge, as a check upon the former as well as a cross check upon the chemist's work and a check also upon the one who weighed the various screen products. These figures also enable us to calculate the distribution of the values carried in the screen products, which is very important.

The way these figures check up is worthy of some comment; considering the fact that the figures representing the assay values of the Feed and Discharge were obtained by roundabout calculations which involved possible errors in taking the weights of the various screen products as well as possible errors in the chemist's figures, and concurrently bearing in mind that small errors, at the start, increase rapidly as the calculations proceed. It must be noted that the final figures check up very closely. This indicates an uncommon degree of accuracy in the chemist's figures and warrants confidence being placed in them.

The figures given in the report respecting the assays and weights of the various screen products resulting from the screen analyses of the various feeds and discharges to and from the Hardinge mills are herein tabulated in the form of percentages by weight and so as to clearly reveal the distribution of values in all the various screen products, as follows:

TABLE I

No. 1: Hardinge 6-Foot Mill
Feed: Oversize From Trommels, Plus Jigg Tailings

CALCULATED ASSAYS

| | Gold, Ozs. | Silver, Ozs. | Lead, % | Zinc, % |
|---|---|---|---|---|
| Feed | 5628 | 2.5099 | 2.1447 | 7.4523 |
| Discharge | 6722 | 2.4714 | 2.6036 | 7.4542 |

FEED

| Grade | % by Weight | Distribution Gold, % | Distribution Silver, % | Distribution Lead, % | Distribution Zinc, % |
|---|---|---|---|---|---|
| + 20 | 29.69 | 18.47 | 27.21 | 24.78 | 21.84 |
| + 40 | 30.47 | 30.85 | 24.29 | 17.48 | 22.41 |
| + 60 | 16.42 | 18.09 | 14.39 | 10.80 | 16.55 |
| +100 | 10.93 | 18.27 | 11.79 | 10.55 | 16.51 |
| +200 | 7.81 | 11.09 | 10.89 | 15.80 | 14.29 |
| −200 | 4.68 | 3.23 | 8.40 | 20.59 | 8.41 |
| | 100 | 100 | 100 | 100 | 100 |

DISCHARGE

| Grade | % by Weight | Distribution Gold, % | Distribution Silver, % | Distribution Lead, % | Distribution Zinc, % |
|---|---|---|---|---|---|
| + 40 | 11.76 | 13.98 | 10.95 | 4.21 | 6.21 |
| + 60 | 21.01 | 18.45 | 14.45 | 9.11 | 13.58 |
| +100 | 21.85 | 22.76 | 21.22 | 14.28 | 21.13 |
| +200 | 21.85 | 22.42 | 23.87 | 23.75 | 28.58 |
| −200 | 23.53 | 22.39 | 29.51 | 48.62 | 30.47 |
| | 100 | 100 | 100 | 100 | 100 |

TABLE II

No. 2 Hardinge 6-Foot Mill
Feed, Jigg Tailings
CALCULATED ASSAYS

| | Gold, Ozs. | Silver, Ozs. | Lead, % | Zinc, % |
|---|---|---|---|---|
| Feed | 3736 | 2.9506 | 2.0039 | 9.3154 |
| Discharge | 4142 | 2.7604 | 1.9661 | 8.6946 |

FEED

| Grade | % by Weight | Distribution Gold, % | Distribution Silver, % | Distribution Lead, % | Distribution Zinc, % |
|---|---|---|---|---|---|
| + 20 | 56.31 | 63.30 | 49.63 | 55.67 | 36.84 |
| + 40 | 15.54 | 10.81 | 14.56 | 13.28 | 14.93 |
| + 60 | 6.80 | 8.57 | 9.46 | 7.37 | 10.53 |
| +100 | 7.75 | 9.18 | 9.97 | 7.00 | 13.32 |
| +200 | 9.72 | 5.97 | 10.21 | 6.54 | 13.85 |
| −200 | 3.88 | 2.17 | 6.17 | 10.14 | 10.53 |
| | 100 | 100 | 100 | 100 | 100 |

DISCHARGE

| Grade | % by Weight | Distribution Gold, % | Distribution Silver, % | Distribution Lead, % | Distribution Zinc, % |
|---|---|---|---|---|---|
| + 40 | 16.66 | 16.90 | 13.19 | 9.57 | 7.36 |
| + 60 | 14.60 | 18.32 | 11.63 | 7.70 | 9.33 |
| +100 | 16.66 | 18.91 | 15.07 | 11.19 | 16.15 |
| +200 | 21.87 | 26.92 | 20.61 | 14.68 | 27.88 |
| −200 | 30.21 | 18.95 | 39.50 | 56.86 | 39.28 |
| | 100 | 100 | 100 | 100 | 100 |

TABLE III

Tube Mill, 3½ Ft. by 16 Ft.
Feed: Coarse Table Middlings Plus Jigg Tailings
CALCULATED ASSAYS

| | Gold, Ozs. | Silver, Ozs. | Lead, % | Zinc, % |
|---|---|---|---|---|
| Feed | .2429 | 2.8212 | 1.8149 | 7.9656 |
| Discharge | .2194 | 2.5169 | 2.1163 | 9.7766 |

FEED

| Grade | % by Weight | Distribution Gold, % | Distribution Silver, % | Distribution Lead, % | Distribution Zinc, % |
|---|---|---|---|---|---|
| + 20 | 60.18 | 57.02 | 59.66 | 53.06 | 35.34 |
| + 40 | 14.10 | 15.08 | 11.56 | 11.74 | 13.47 |
| + 60 | 7.01 | 6.62 | 6.70 | 6.91 | 14.97 |
| +100 | 8.77 | 12.98 | 10.86 | 9.13 | 22.14 |
| +200 | 7.60 | 5.32 | 7.00 | 5.53 | 9.93 |
| −200 | 2.34 | 2.98 | 4.22 | 13.63 | 4.15 |
| | 100 | 100 | 100 | 100 | 100 |

DISCHARGE

| Grade | % by Weight | Distribution Gold, % | Distribution Silver, % | Distribution Lead, % | Distribution Zinc, % |
|---|---|---|---|---|---|
| + 40 | 21.18 | 13.51 | 9.15 | 8.50 | 6.35 |
| + 60 | 16.47 | 15.01 | 9.06 | 7.32 | 1.53 |
| +100 | 23.53 | 31.11 | 29.79 | 18.90 | 35.82 |
| +200 | 23.53 | 25.74 | 29.79 | 23.02 | 35.00 |
| −200 | 15.29 | 14.63 | 22.21 | 42.26 | 21.30 |
| | 100 | 100 | 100 | 100 | 100 |

TABLE IV

Hardinge 4-Foot Mill
Feed; Jigg Middlings
CALCULATED ASSAYS

| | Gold, Ozs. | Silver, Ozs. | Lead, % | Zinc, % |
|---|---|---|---|---|
| Feed | .4785 | 5.3377 | 1.5235 | 2.6038 |
| Discharge | .8936 | 6.4211 | .9141 | 2.4807 |

FEED

| Grade | % by Weight | Distribution Gold, % | Distribution Silver, % | Distribution Lead, % | Distribution Zinc, % |
|---|---|---|---|---|---|
| + 20 | 46.34 | 58.10 | 45.16 | 52.33 | 59.05 |
| + 40 | 12.20 | 16.32 | 13.02 | 12.80 | 15.17 |
| + 60 | 7.32 | 5.52 | 6.16 | 9.00 | 6.42 |
| +100 | 8.54 | 5.71 | 6.88 | 4.60 | 5.76 |
| +200 | 14.63 | 7.94 | 16.45 | 9.39 | 8.42 |
| −200 | 10.97 | 6.41 | 12.33 | 11.88 | 5.18 |
| | 100 | 100 | 100 | 100 | 100 |

DISCHARGE

| Grade | % by Weight | Distribution Gold, % | Distribution Silver, % | Distribution Lead, % | Distribution Zinc, % |
|---|---|---|---|---|---|
| + 60 | 2.44 | Not enough for assay | | 2.00 | 2.30 |
| +100 | 12.19 | 13.64 | 17.08 | 7.60 | 11.05 |
| +200 | 34.15 | 47.38 | 28.70 | 41.09 | 36.49 |
| −200 | 51.22 | 38.98 | 54.22 | 49.31 | 50.16 |
| | 100 | 100 | 100 | 100 | 100 |

There appears nowhere in the report any information respecting the degree of fineness to which the ore must be crushed in order to free the greater part of the various mineral values. This knowledge is of the utmost importance to one who has in hand the task of recovering values in any ore and particularly one like this under discussion. One may find some warrant in assuming that this ore is being, in the very first stages, too finely ground, from the fact that the statement is made that a certain amount of tailings is rejected from the table treating the coarsest grade of minus 1 mm feed. We may therefore for the moment assume that ore 0.0122 in., is fine enough to free such a large percentage of the minerals as to produce, in the concentrating department, not too great a proportion of middlings. On this assumption let us see what has been done in the grinding mills; taking each one of the four tables of figures separately and finding the percentage, by weight, of the material that is coarser than 60 and comparing it with that which is finer and concurrently comparing distribution of values; thus, in this manner, finding out how much unnecessary and really undesirable and actually harmful work is being done in the grinding mills. Any quantity of ore being ground beyond the degree of fineness necessary to free the respective minerals is decidedly harmful, always.

TABLE I-A

FEED

| Grade | % by Weight | Distribution Gold, % | Distribution Silver, % | Distribution Lead, % | Distribution Zinc, % |
|---|---|---|---|---|---|
| +60 | 76.58 | 67.41 | 65.92 | 53.06 | 60.80 |
| −60 | 23.42 | 32.59 | 34.08 | 46.94 | 39.20 |
| | 100 | 100 | 100 | 100 | 100 |

DISCHARGE

| Grade | % by Weight | Distribution Gold, % | Distribution Silver, % | Distribution Lead, % | Distribution Zinc, % |
|---|---|---|---|---|---|
| +60 | 32.77 | 32.43 | 25.40 | 13.35 | 19.82 |
| −60 | 67.23 | 67.57 | 74.60 | 86.65 | 80.18 |
| | 100 | 100 | 100 | 100 | 100 |

TABLE II-B

FEED

| Grade | % by Weight | Distribution Gold, % | Distribution Silver, % | Distribution Lead, % | Distribution Zinc, % |
|---|---|---|---|---|---|
| W60 | 78.65 | 82.68 | 73.65 | 76.32 | 62.30 |
| W60 | 21.35 | 17.32 | 26.35 | 23.68 | 27.30 |
| | 100 | 100 | 100 | 100 | 100 |

DISCHARGE

| Grade | % by Weight | Distribution Gold, % | Distribution Silver, % | Distribution Lead, % | Distribution Zinc, % |
|---|---|---|---|---|---|
| +60 | 31.26 | 35.22 | 24.82 | 17.27 | 16.69 |
| −60 | 68.74 | 64.78 | 75.18 | 82.73 | 83.31 |
| | 100 | 100 | 100 | 100 | 100 |

TABLE III-C

FEED

| Grade | % by Weight | Distribution Gold, % | Distribution Silver, % | Distribution Lead, % | Distribution Zinc, % |
|---|---|---|---|---|---|
| +60 | 81.29 | 78.72 | 77.92 | 71.71 | 63.78 |
| −60 | 18.71 | 21.28 | 22.08 | 28.29 | 36.22 |
| | 100 | 100 | 100 | 100 | 100 |

DISCHARGE

| Grade | % by Weight | Distribution Gold, % | Distribution Silver, % | Distribution Lead, % | Distribution Zinc, % |
|---|---|---|---|---|---|
| +60 | 37.65 | 28.52 | 18.21 | 15.82 | 7.88 |
| −60 | 62.35 | 71.48 | 81.79 | 84.19 | 92.12 |
| | 100 | 100 | 100 | 100 | 100 |

TABLE IV-D

FEED

| Grade | % by Weight | Distribution Gold, % | Distribution Silver, % | Distribution Lead, % | Distribution Zinc, % |
|---|---|---|---|---|---|
| +60 | 65.86 | 79.91 | 61.34 | 74.13 | 80.64 |
| −60 | 34.14 | 20.06 | 35.66 | 25.87 | 19.36 |
| | 100 | 100 | 100 | 100 | 100 |

DISCHARGE

| Grade | % by Weight | Distribution Gold, % | Distribution Silver, % | Distribution Lead, % | Distribution Zinc, % |
|---|---|---|---|---|---|
| +60 | 2 44 | Not enough for assay | | 2.00 | 2.30 |
| −60 | 97.56 | 100 | 100 | 98.00 | 97.70 |
| | 100 | 100 | 100 | 100 | 100 |

It will be seen at once that in every instance much of the feed going to the grinding mills is already fine enough; this being true, why should it be further punished by passing through the slaughter house? In detail we see in the Feed in Table I A 23.42 per cent minus 60 mesh; in Table II B 21.35 per cent; in Table III C 18.71 per cent and in Table IV D 34.14 per cent. The immediate effect of passing this fine material through the mills is to largely increase the already too high percentage of slimes. In practice it might be found desirable to classify at as coarse a grade as 50 mesh; say 0.0146 in. instead of 60 mesh 0.0122 in., or at some point in between, or it may be found that even a coarser grade would be desirable.

The work done, as represented by Table I A is particularly bad, inasmuch as the 23.42 per cent by weight, of the FEED carries, in the minus 60 mesh grade, 46.94 per cent of the total Lead content; while in the DISCHARGE we find, in the same grade, 67.23 per cent by weight, carrying 86.65 per cent of the total Lead content; and of this 86.65 per cent of Lead 48.62 per cent has already been crushed to pass a 200 mesh screen; much of this, no doubt, is almost as fine as pigment and on this account it is extremely difficult, if not impossible to recover its Lead and other values. All the other tables could be discussed in the same manner and the same general conditions found to exist.

We have no information with respect to the relative tonnage of feed going to the pebble mills, respectively, for then it would be well worth while to ascertain, definitely, what percentage of the total values in the ore is ground finer than 200 mesh. But since the percentages, by weight, of all the screen products passing to and from the machines and their assay values have been thrown into percentage tables to show the distribution of values, it might be well to note the following:

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Table | I. | Minus | 200, | carries | 48.62% | Total Lead and | 30.47% | Total Zinc |
| " | II. | " | 200, | " | 56.86% | " " " | 39.28% | " " |
| " | III. | " | 200, | " | 42.26% | " " " | 21.30% | " " |
| " | IV. | " | 200, | " | 49.31% | " " " | 50.16% | " " |

It will be readily seen by reference to the tables that fully 1/3 of the minus 200 mesh, reporting in the DISCHARGE was not made in the pebble mills, but was passed in as feed when it was already fine enough to pass a 200 mesh screen. It is fair to assume that this minus 200 mesh feed which passed into the machine was therein ground still finer. It appears therefore that so far as this part of the work is concerned, the practice carried on in the grinding department would be much better suited for a paint works than for a concentrating mill.

This digest of the work, done in the grinding department, clearly indicates that not far from 50 per cent of all the Lead carried in the jigg tailings and middlings was ground fine enough to pass a 200 mesh screen and much of this 50 per cent was ground to a degree of fineness closely approaching that of pigment. This in itself goes a long way to show the reason why there was made, in the operations, such low percentages of final recovery.

If and when necessary changes and adjustments have been made looking towards a radical reduction of the percentage of fines and slime produced, and when a minimum has been reached, there is no reason why a satisfactory recovery of their contained values cannot be made, provided they are carefully and properly classified and passed over a good slime table.

In this connection it may be said that last summer while making some tests for the purpose of deciding upon the best way to treat fines and slimes of this character and to make a selection of the best slime table to use for the purpose, we had a quantity of "tankage" carrying values in Zinc and Lead, all of which was fine enough to pass a 200 mesh screen. This was passed through an improved classifier, which had then lately been designed and put on the market. The objective point was to wash away nothing but the true slime or colloidal matter, which was sent to waste as being unamenable to further mechanical treatment. From the oversize, or underflow, there was made a Lead product, carrying 77 per cent Lead, every bit of which would pass a DuFour silk cloth screen of 275 mesh; and a Zinc product carrying 51 per cent Zinc. This is only mentioned to show what can be done with a minus 200 mesh product, only provided it has not previously been pulverized to actual slime, and provided it is properly classified, and a suitable slime table used to further treat it.

On Page 23, of the report, there appears a remark to the effect that "while the work of the Hardinge Mills is satisfactory with respect to grinding Tailings, they have not done so well in the work of grinding Middlings, on account of producing too much mineral slime." There is very substantial ground upon which to base a belief that the fault has not been so much with the Hardinge Mill itself, as with the way these machines have been handled and the character of the feed passing to them. Refer for instance to

TABLE No. 4; Four foot Hardinge Mill, grinding Jigg Middlings. Observe that 34.14 per cent, by weight, of the FEED was already finer than 60 mesh; and 10.97 per cent was minus 200 mesh; while in the DISCHARGE 97.56 per cent was finer than 70 mesh and 51.22 per cent was finer than 200. This 34.14 per cent, by weight, of the FEED, finer than 60 mesh, should probably have bypassed the Hardinge, and certainly so, provided the greater part of it consisted of free mineral particles; but at any rate, the 10.97 per cent by weight, which was finer than 200 mesh, should have bypassed. The remaining 65.86 per cent (plus 60 mesh) or at most, the 74.40 per cent (plus 100 mesh) should have been passed through the Hardinge rapidly, in the effort to grind it only fine enough to pass a 60 or a 100 mesh screen, as the case might be, but surely not to so severely pulverize it. The oversize to be returned to the Hardinge, after classification.

It must be borne in mind that the efficiency of Rolls falls away alarmingly when they are put to the work of such fine grinding as is necessary in this case. The wisdom of making the proposed change from Hardinge Mills to Rolls is therefore very much to be questioned.

There are several well known ways to regulate the performances of the Hardinge Mills, so as to make the results conform pretty fairly well with current requirements.

In treating an ore like the one under discussion, and in which the mineral constituents are very friable and strongly tend to break down into slimes, grinding operations should be carried on with these features and conditions kept well in mind. It certainly is necessary to classify the feed, so as to deliver to the mill no material that has already been ground fine enough to physically free the mineral particles. It is equally necessary to classify the discharge and to return the oversize. When this practice is carried on and when proper adjustments have been made, it will be found that there will be a very marked decrease in the quantity of true slimes that is produced.

After a careful study of the report, as published, and the digest of the same as given herein, we believe it will be seen that by making some changes in the grinding department looking towards a system of step grinding for the purpose of effecting a gradual fine granulation of the ore particles, as opposed to a too sudden and violent pulverization, a great improvement can be made over the indifferent recoveries that it will be seen are now being effected. To the proposed changes to be made in the Grinding Department there could also, to good advantage, be added a certain number of classifiers, located at various points in the system to enable the ore to bypass the grinding department as soon as it has reached the degree of fineness necessary to free the mineral particles; letting the jigg and table work be such, as to pass for regrinding, substantially, only such middlings as are true Middlings (attached particles) and to inaugurate a better system of treating the fines and slimes after they have been radically reduced in quantity.

6 Beacon St., Boston, Mass.

---

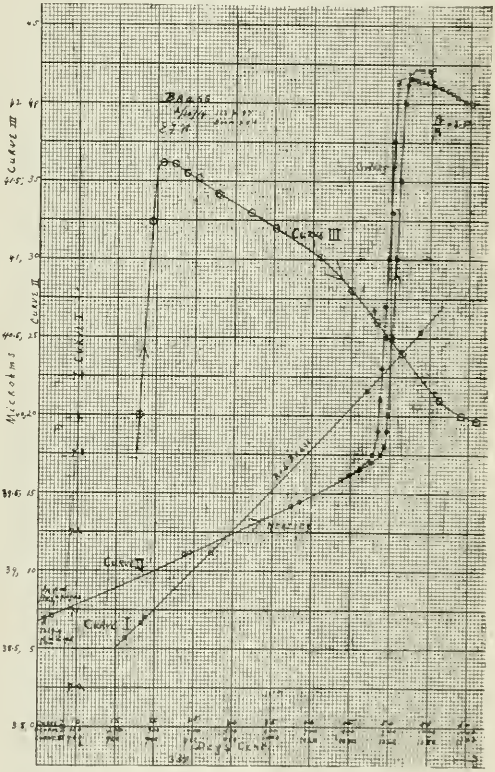
**A submarine oxyhydrogen torch** is reported to have been tested in Kiel harbor, Germany, for the purpose of testing the possibility of dismantling sunken vessels. A 4-inch iron case was cut in half a minute.

## Resistivity of Brass; Solid and Molten

BY EDWIN F. NORTHRUP

It has been pointed out to the writer that, in designing certain types of electric furnaces for the treatment of molten brass, an accurate knowledge of the electrical resistivity of this alloy in the molten state would be useful. As both the method and equipment for making this determination were available, the writer decided to measure in both the solid and liquid state the resistivity of ordinary rod brass and publish the data for the benefit of any one who might find it useful.

Alloys, which pass under the name of brass, are of very variable composition and a complete specification of the particular alloy for which data were obtained would require the making of an accurate chemical analysis. This the writer did not feel justified in undertaking.[1] The brass used in the measurement was the ordinary rod brass, in rods about 0.3 cm in diameter, commonly used in the machine shop. Its quality is, to a certain extent, determined by a knowledge of its density. The density of the rod brass was, therefore, determined by a measurement of the mass and the volume of a rod about 91 cm long, and found to equal 8.472. Its specific resistance while in the form of a rod was also determined with precision in the temperature range 16.25° C. to 53.70° C. Curve I and the table record the results obtained. With this much exact



RESISTIVITY CURVES

---

[1] After this article had been put into print, an analysis was made by courtesies of the Ajax Metal Company, with the knowledge and consent of Dr. Northrup, of pieces of the same lot of brass used in his determinations, and it was found to contain 63% copper, 34.58% zinc, 2.42% lead, and traces of tin and iron.—Carl Hering.

information, respecting the nature of the brass used in the measurements, it is thought that the data obtained apply to a material of sufficiently definite composition to meet engineering requirements, and to serve the designer with information sufficiently precise for his purposes.

The method of measurement employed for measuring the resistivity of the brass from a temperature at which it was molten down to room temperature, and again from room temperature up to 1104° C., was in all essential respects the same as that employed by the writer in measuring the "Resistivity of Copper in Temperature Range 20° C. to 1450° C." published in the *Journal* of the Franklin Institute, January, 1914. The furnace employed in measuring brass and all other materials to a temperature of 1600° C. or more has already been described in METALLURGICAL AND CHEMICAL ENGINEERING, January, 1914.

Considerable precaution must be exercised in measuring an alloy like brass, one of the constituents of which has a low vaporization temperature. Thus the vaporization temperature of zinc is given as 918° C. If the brass is raised, therefore, to a temperature at which the zinc volatilizes, not only is the composition of the brass altered in the course of the measurement, but the measurement is interfered with by the vapor of zinc (which being in a CO atmosphere does not oxidize) congealing on the under surface of the furnace cover, thus short-circuiting the molybdenum wire terminals employed.

The first time the measurement was attempted these results were not foreseen and the furnace was brought to a temperature of a little over 1200° C. before the container was filled with brass. The result was that a goodly proportion of the zinc distilled out of the brass and deposited a thick layer of metallic beads on the lower surface of the furnace cover. Fortunately the construction of the furnace is such that no injury happened to the furnace.

After this experience the container was heated before filling with brass to a temperature of only 1020° C., and immediately allowed to cool, readings of temperature and resistivity being taken as the cooling proceeded (see curve II). After the container had cooled to 19.4° C. the resistivity was measured again with rising temperature and the temperature was carried this time to 1104° C. (See curves II and III). The agreement at 972° C. between the cooling and the heating curves, at which temperature the brass is molten, was exact. At 940° C. the difference between heating and cooling resistivity is 0.42 per cent.

After the measurement was over it was found that a very small amount of zinc had distilled out of the brass, the maximum temperature reached being, as above stated, 1104° C. Since pure zinc is said to vaporize at 918° C. it follows that when zinc is alloyed with copper the vaporization of zinc occurs at a higher temperature. The vaporization appears to be inappreciable until a temperature of nearly 1090° C. is reached. Since the resistivity is very sensitive to changes in the composition of the material, and since the writer has now so perfected the method of measuring the resistivity of a molten metal or alloy that the error need not exceed 0.1 of one per cent, determinations of resistivity might be employed with advantage for determining alterations in composition of alloys due to vaporization or other causes.

Referring now to the curves we invite attention to the following points: The resistivity of the rod brass is 7.101 microhms per centimeter cube at 20° C. and 7.550 microhms at 50° C. This gives as the coefficient of rod brass, reckoning from 20° C., 0.0021. Thus brass increases in resistance with raise of temperature about one-half as fast as copper in the solid state. The increase is not quite linear, curve I being very slightly convex toward the temperature axis.

The resistivity of the brass which had been cooled from the molten state in the container measured 6.957 microhms at 20° C. It was probably somewhat less than this, because the brass in cooling in the container from the molten state must suffer some shrinkage and the measurement gives the volume and not the mass resistivity of the brass. We conclude, therefore, that the resistivity of brass which has been slowly cooled from the molten state is at least 2 per cent less at 20° C. than the resistivity of the same brass when drawn into a rod. The ratio of the resistivity of the brass just after fusion is complete, to the resistivity just before fusion starts, is 2.37+. This is a very large increase in resistivity in passing from the solid to the molten state and is about 18 per cent greater than in the case of many of the pure metals.

The change in the resistivity with increase in temperature in the molten state is plotted on an enlarged scale in curve III. It is interesting to note that the resistivity *decreases* with increase in temperature. The writer has shown in a joint article by E. F. Northrup and V. A. Suydam, *Journal* of the Franklin Institute, February, 1913, that zinc has a strongly negative temperature coefficient in the molten state up to a temperature of 750° C. This constituent of the brass apparently determines the slope of the curve in the molten state. The fact that curve III begins to show an inflection at about 1090° C., the decrease in the resistivity becoming less rapid, indicates that it is at about this temperature that the brass begins to lose some of its zinc by vaporization. If all the zinc were to vaporize out the curve would become like that for copper, which shows a strongly positive coefficient at all temperatures up to the highest measured, which was 1450° C.

TABLE I.

| Temp. Degs. C. | Microhms per cm cube | Ratio of resistivity at two temps. | Notes |
|---|---|---|---|
| 20... | 7.101.... | $\frac{\rho_{1000}}{\rho_{20}} = 5.922$ | Rod brass<br>Density = 8.472 |
| 20... | 6.957.... | $\frac{\rho \text{ liquid}}{\rho \text{ solid}} = 2.37+$ | Cooled slowly from molten state |
| 50... | 7.55 | ........................ | Rod brass |
| 944... | 41.61 | ........................ | Heated slowly from solid state |
| 1000... | 41.20 | ........................ | Heated slowly from solid state |
| 1084... | 40.11 | ........................ | Heated slowly from solid state |

The writer in measuring the resistivity of the pure metals confirmed all his results by making each measurement twice, each time in a different container. The above measurements on brass were only made once, as the variable composition of this material is such that there would be no justification for the expenditure of a large amount of time to obtain very high accuracies. However, the writer believes that the data given in curve I may be relied upon to within 0.2 of one per cent and that in curve III to within 0.5 of one per cent.

The examination of the resistivity curves of the alloys is now, certainly, a matter of routine, if one is provided with a suitable equipment, and the writer believes that these curves would give very considerable information to metallurgists respecting the properties and the behavior of alloys. He hopes to see, in the near future, many measurements of the above character made and published.

Palmer Physical Laboratory, Princeton, N. J

---

**The Chirese iron and steel trade** has been upset by revolutionary disturbances during the past two years. Both imports and exports of iron and steel products fell off remarkably in 1912 as compared with 1911, and the 1913 business has not returned to normal. A new 300-ton blast furnace is in course of construction at Hanyang, and another at Tayeh.

# Industrial Synthetic Production of Sodium Cyanide*

BY CAMILLE MATIGNON

Among the nitrogen compounds nitric acid, ammonia, and cyanide, the last one is only of secondary or minor industrial importance as compared with the other two. Chile supplies the world annually with 2,500,000 tons of sodium nitrate; the manufacture of gas and coke for metallurgical purposes furnishes the market with 1,000,000 tons of ammonium sulphate; the cyanide industry, on the other hand, is limited annually to from 20,000 tons to 25,000 tons of cyanide compounds, in the form of sodium and potassium cyanide, ferrous and ferric cyanide and Prussian blue.

The use of cyanides has increased particularly since the introduction of the Arthur and Forrest process of gold extraction in the year 1888. Before that time the annual production of cyanide of potassium, which was the only alkali cyanide then in use, did not exceed 100 tons; it reached 450 tons in 1888; from then on it increased annually by about 1000 tons of potassium cyanide and sodium cyanide, the latter having been introduced into the market in the meantime. Almost the whole quantity of alkali cyanides is used for the gold extraction process; the gold and silver plating industry consume only an inconsiderable amount of cyanides.

As said before, the cyanide compounds are only of secondary importance as to quantity in the industry of nitrogen compounds. On the other hand, as to price the nitrogen of the cyanide is much more valuable than nitrate nitrogen or ammonia nitrogen. The value of these latter two does not exceed 13.6 cents per pound, while the price of cyanide nitrogen reaches and exceeds 54 cents per pound. Under such conditions it should be worth while to convert nitric acid or ammonia into cyanide.

There are several reactions by which these transformations can be achieved. None of them has been made use of practically for transforming sodium nitrate into sodium cyanide, while ammonia is actually used for the manufacture of cyanides. The inverse reaction is much more easily carried out; cyanide produces easily ammonia when heated in a current of steam. Hydrocyanic acid, which is the nitrite of formic acid, has a tendency to decompose into ammonia and formic acid, and the salts of hydrocyanic acid give ammonia and formates. The formates are decomposed at red heat and only alkali carbonate remains when sodium cyanide is heated. $2\,CN\,Na + 4\,H_2O = 2\,NH_3 + Na_2CO_3 + CO + H$.

A great number of research chemists are occupied at the present time with the industrial problem of the synthesis of ammonia by way of the cyanides. This seems to me to be illogical, for hydrocyanic acid is a substance which when produced from its elements absorbs heat:

$$C + N + H = CNH - 30.5 \text{ cal.}$$

and it will always be more expensive than ammonia, the heat of formation of which is exothermic:

$$N + 3\,H = NH_3 + 12 \text{ cal}$$

The electrolytic production of sodium with melted sodium hydroxide as electrolyte has put us into a position to produce sodium very cheaply. Starting from sodium and from ammonia, a process has been elaborated which supplies the metallurgy of gold with a considerable amount of the cyanide it needs.

The English factory of Castner is intimately connected with the history of sodium and there the preparation of sodium, and subsequently that of cyanide, was first studied; but only with the improvements introduced by the Deutsche Gold und Silberscheide Anstalt of Frankfurt did the manufacture of cyanide become an industrial process.

On examining the formula of sodium cyanide CN Na (N = 14 and Na = 23) it will be seen that 1 lb. of cyanide nitrogen requires 1 lb. of ammonia nitrogen and about 2 lbs. of sodium. Taking 13.6 cents as the price of 1 lb. of ammonia nitrogen, and 54.4 cents as the value of 1 lb. of cyanide nitrogen, there remains a difference of 40.8 cents to cover the cost of 2 lbs. of sodium plus the cost of transformation and profit. As the electrolytic process of Castner with cheap electric power can produce 1 lb. of sodium at 9.05 cents or 18.1 cents for 2 lbs. there remains finally a margin of 22.7 cents to cover the cost of manufacture and profit.

## I. Original Castner Process

### 1. THE PRINCIPLE OF THE PROCESS.

Ammonia gas is absorbed by sodium at 400° C. with the formation of amid and the liberation of hydrogen.

$$NH_3 + Na = NH_2Na + H$$

This amid, when melted with one molecule of sodium cyanide is converted into sodium cyanamide between 550° and 600°.

$$NH_2Na + CN\,Na = CN_2Na_2 + H_2$$

Finally, this cyanamide, intimately mixed with carbon, fixes the latter at 750° to 800° with the formation of cyanide.

$$CN_2Na_2 + C = 2CNNa.$$

The molecule of cyanide which has served as intermediary, is thus recovered.

By proceeding in a different manner, the use of this intermediary molecule of cyanide can be avoided. A first carbon atom converts two molecules of amid into sodium cyanamide.

$$2NH_2Na + C = CN_2Na_2 + 2H_2.$$

Further on at 800° a second atom of carbon produces cyanide.

$$CN_2Na_2 + C = 2CNNa.$$

Castner's first idea was to produce cyanide from elementary nitrogen. When looking at the equation

$$2C + 2Na + N_2 = 2CNNa + 50 \text{ cal},$$

we find only one gaseous substance, the other two being solid or liquid; the enormous quantity of 50 cal for one gaseous molecule leaves no doubt of the possibility of the reaction. This, in fact, I had proved before I knew of Castner's experiments.

A current of pure nitrogen passing over a mixture of carbon and sodium has given me cyanide, although the yield in two or three preliminary trials has not been high. Castner had already made similar experiments in 1894. He poured molten sodium slowly over carbon heated in a vertical cylinder, while a current of nitrogen entered the cylinder sideways. The cyanide formed ran off at the bottom. The yield of cyanide was thus greater than by sending the nitrogen into the mixture of carbon and sodium. Castner soon found, however, that it was better to replace the elementary nitrogen by ammonia gas.

In the first period of the manufacture of cyanide, Castner operated successively in two apparatuses. The first one served for the production of sodium amid at 300-400°, the second one converted the amid into cyanide at 700-800°.

### 2. PREPARATION OF SODIUM AMID

Sodium is acted upon by ammonia in a horizontal rectangular retort A, the bottom of which is slanting, in order to facilitate the movement of the products (see Fig. 1). That part of the retort above the liquid metal M is divided into compartments by means of

---

*From *Revue Generale des Sciences*, Vol. 24, pp. 882-86 (1913), translated by Alex F. Fuerst.

vertical partitions C which touch the metallic bath; each of these partitions is fixed ultimately to opposite sides of the retort, as shown in Fig. 2, in order to force the ammonia gas to circulate from one compartment to the other and thus to remain as long as possible in contact with the sodium.

To operate the apparatus, the retort is heated to 300-400° C.; well dried ammonia gas is then sent through the retort in order to replace the air contained in it. The apparatus is then filled through funnel D with melted sodium until it overflows at G and tends to run away through the siphon J; the ammonia gas which is continually introduced through N is gradually absorbed on the surface of the sodium.

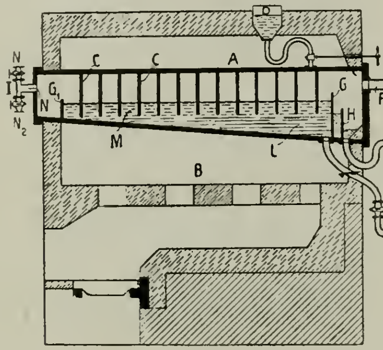


FIG. 1—VERTICAL CUT THROUGH APPARATUS FOR THE MANUFACTURE OF SODIUM AMID

A, Horizontal Retort; B, Furnace Room; C, Vertical Partitions; M, Liquid Metal; D, Funnel for the Introduction of Melted Sodium; N, Entry for Ammonia Gas; Exit for Hydrogen Gas; T, Siphon; E, K, $N_1$ and $N_2$, stop cocks.

The sodium amid which forms is also liquid and as it is heavier than sodium it tends to sink to the bottom of the metallic bath, leaving always pure sodium exposed to the ammonia. The amid passes through a small opening in the partition G into M and can be withdrawn through the siphon J. The ammonia gas is absorbed in theoretical amounts. The hydrogen escapes through F. The amid has become of considerable importance lately as it is required in the synthetic production of indigo from phenylglycine.

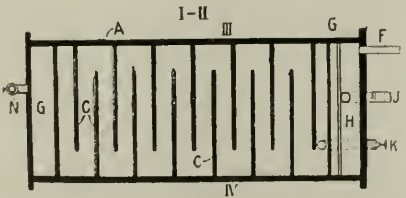


FIG. 2—PLAN OF APPARATUS ALONG I II

### 3. MANUFACTURE OF THE CYANIDE

The conversion into cyanide takes place in a cylindrical vertical retort A (Fig. 3) with a conical bottom. The retort is filled with wood charcoal through the funnel C, and heated to 800° C.; melted sodium amid is then gradually introduced; hydrogen escapes through F while molten cyanide runs off through the siphon E into molds where it solidifies.

### II. Castner-Roessler Process

Roessler, of the Deutsche Gold und Silberscheide Anstalt of Frankfurt, found that the yield in the second operation could be considerably improved. He found it to be the resultant of two consecutive reactions. At the temperature required for the conversion into cyanide, the sodium amid already undergoes decomposition with liberation of nitrogen and the yield is that much less. Moreover, some sodium cyanamide is found to be present in the cyanide; and the quantity of the cyanamide increases with the lowering of temperature. Thus when sufficient heat is applied some of the amid is decomposed and if the heat applied is not sufficient an increasing amount of cyanamide instead of cyanide is formed.

After much study, Roessler succeeded in obtaining an almost quantitative conversion of ammonia into cyanide by conducting the whole operation in three phases. Formation of amid, transformation into cyanamide, and conversion into cyanide. The second operation takes place at the low temperature of 300-400°, and consequently under conditions in which the amid is stable; further the cyanamide is not decomposed at 800° C., the temperature which is required for conversion into cyanide.

As we have already shown, the conversion of amid into cyanamide may be carried out in two different ways; either by melting the amid together with an equivalent amount of cyanide:

$$NH_2Na + CNNa = CN_2Na_2 + 2H_2,$$

or by heating the amid at 350-400° with charcoal,

$$NH_2Na + C = CN_2Na_2 + 2H_2.$$

This latter is one of the most remarkable reactions since hydrogen is replaced by carbon.

This operation is carried out as follows: The amid is melted with very finely divided carbon; as soon as a temperature of 380° C. is reached a violent development of hydrogen takes place; at the same time the whole mass loses its fluidity while the reaction proceeds, because the melting point of ordinary cyanamide lies at 550° C. For the completion of the reaction it is, therefore, necessary to raise the temperature gradually to 550 or 600°. Under these conditions the yield of cyanamide is quantitative.

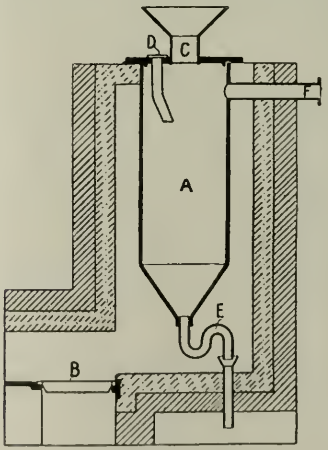


FIG. 3—CASTNER'S APPARATUS FOR CONVERTING SODIUM AMID INTO CYANIDE

A, Retort; B, Furnace Room; C, Funnel for the Introduction of Wood Charcoal; D, Opening for the Introduction of Melted Sodium Amid; E, Syphon for the Removal of the Cyanid.

The need of very finely divided carbon is self-evident, since each molecule of amid must find the required amount of carbon for its conversion. The replacement of carbon by liquid or gaseous hydrocarbons has been proposed and the same result is thereby much more easily achieved; acetylene particularly allows of a very rapid reaction, but its use increases the cost.

The process is carried out as follows by the Deutsche Gold und Silberscheide Anstalt and by those companies which are its licensees.

The various phases of the operation are carried out successively in one apparatus, which consists of a number of large iron crucibles. Each crucible is charged with 70 kilograms (about 156 lbs.) of finely divided wood charcoal. Ammonia is passed slowly over the crucible at 500° in order to replace the air; then the current of gas is increased, and 100 kilograms (223 lbs.) of sodium are added. The temperature is slowly raised to 600° C., which is the temperature required for conversion into cyanamide. Under these conditions, neither ammonia nor amid is decomposed. For the conversion into cyanide the temperature is finally raised 800° C. All that is necessary immediately to obtain a commercial product without any further treatment is to let the melted cyanide run into molds. The yield is quantitative, no losses are experienced except those inherent in every manufacturing operation. All that is required is a rigid control of temperatures. The cyanide thus prepared contains 90 to 98 per cent pure cyanide and is equivalent to 120 to 130 per cent of cyanide of potassium, which is the current method of valuation of cyanide.

The Castner process, with these improvements, is used by the Deutsche Gold und Silberscheide Anstalt in their works near Frankfurt; also by the Electrochemische Fabrik Natrium at Rheinfelden; in the United States by the Roessler & Hasslacher Chemical Company; in France by the Société d'Electrochimie. The latter company manufactures sodium in their works at Clavaux (valley of the Romanche, Isere), and manufactures the cyanide at Villers dans l'Oise, the place where Gall and Montlaur carried out their process for the manufacture of potassium chlorate.

Of the 25,000 tons of the annual world production of cyanide, Germany produces one-third, of which she exports about 7000 tons; England is next with a slightly smaller amount, then comes France and the United States, which also manufacture considerable amounts of cyanide.

The Castner-Roessler process, which is the youngest in the cyanide industry, is now of greatest commercial importance; the simplicity of the apparatus and the high yield of the process allow the manufacture of cyanide at a price which defies competition. The question, however, arises, if its future is quite secure.

A new industry is in process of formation, namely that which makes use of the residues which are so cumbersome to distilleries and sugar factories. Numerous and varied products are already being extracted from these residues, for instance, trimethylamin, which is subsequently converted into cyanide. A trial plant which has been erected at Nesles (Oise) produces already 2000 tons of cyanide per year and could produce 3000 tons. When this industry will be extended to its full capacity and when other plants are erected in sugar refining and distilling centers, the production of cyanide should rapidly exceed the consumption. Cyanide will then become a by-product. The cost of manufacture will only depend on the cost of conversion (by simply heating the trimethylamin) and of the necessary soda for the absorption of the hydrocyanic acid formed:

$$(CH_3)_3N = CNH + 2CH_4.$$

Under such conditions it seems possible that the selling price be lowered to such an extent as to defy any and all competition.

*College de France, Paris.*

---

**The International Smelting & Refining Co.** has awarded to the American Bridge Co. a contract for the construction of its new smelter at Miami.

---

# Electro-Metallurgy of Iron and Steel

BY WOOLSEY MCA. JOHNSON

So much has been written and so much has been said on the details of the above subject that it is of little use to expatiate on it. But the view "en perspectif" of an outsider should give conclusions whose usefulness may be great, according as his vision is clear. Now, the architectonics of the electro-metallurgy of iron and steel is at present somewhat ill-defined, as may be evidenced by the waiting game that iron and steel manufacturers are here and elsewhere playing.

The commercial importance of steel is greater than that of gold, silver, zinc, copper and lead combined, and indeed the trite saying that this age is the iron age is well founded. The commercial importance has a direct bearing on any electrical applications, for so important a metal has been the study of many able minds and the endeavors of many noble wills have been here adduced.

The net practical effect is that the iron blast furnace is the most efficient metallurgical instrument that exists. For instance, its thermal efficiency often exceeds 40 per cent and the saving of labor is likewise satisfactory, for a well-designed blast-furnace plant will have a charge of 30 cents per ton of ore for labor. The open-hearth and Bessemer practice has likewise been brought to a state of "temporary perfection." Economies of different nature have been introduced into the iron and steel industry, as for example, the by-product coke oven in connection with an iron works, gas engines working on blast-furnace gas, the Gailey dry-blast apparatus, and the manufacture of slag cement.

It thus can be reasoned with surety that any electro-metallurgical improvement can only succeed here because of innate fitness. The competition of the existing metallurgical art is active and severe, and more so, I believe, than is the case with any other metal. Possible and potential competition of pyro-metallurgical improvements, e. g., the oxygen-enriched blast, cannot be neglected or depreciated in a review of the subject.

Probably the only serious weakness of the iron furnace is its inability to control rigidly the quality of pig iron and the only serious weakness of the steel business is to make in quantity and at a price commensurate with the demands and needs of civilization steel of quality.

In 1902, at the Niagara Falls meeting of American Electrochemical Society, I commented as follows: "In regard to the making of steel by electro-metallurgical means, I would say that the person who attempts it competes against a 'steam-shovel' proposition. A very large part of the iron ore comes from the shores of Lake Superior, is mined by the steam shovel, is very high grade, and consequently the cost of mining, per pound of iron turned out, is very low. In the case of magnetite, I believe Mr. Ruthenburg intends to treat lean ores. In that case, the cost of mining and crushing is all multiplied by two or three, and sometimes by four or five, according to the percentage of iron in the ores. Therefore, it seems to me that any electro-metallurgical process of making steel can only be successful provided the article which is made is so much better that it compensates for its higher cost. For instance, if the steel is made very hard and free from blowholes, and has no dissolved gases in it, it has a physical texture which might compensate for its higher cost. Ordinary steel, made very cheaply, is good enough for most purposes, and steel made electro-metallurgically must be of the grade of crucible steel. Otherwise the process has no economic value." (Transactions of the American Electrochemical Society, Vol. II, pp. 99-100.)

Like any broad statement this must be construed broadly, but under such construction it still analyzes a rich percentage of truth.

While in the distant and hazy future the iron electric furnace to my mind has certain pregnant chances for general application even in such centers as Chicago or Duluth, especially as the character of future workable ores may modify the iron business, yet for the immediate future even such locations as Norway, Chile and California present but little hope of financial good fortune. The past practical success only exists as a figment of the imagination of the bold pioneer, though the present status is not unpromising in certain places.

It might be thought that with power at $6 per electrical horse-power year, approximately the thermal equivalent of coke at $8 per ton, with cheap ore and with a ready market for the product that the honest efforts of the Norwegian and Swedish pioneers would have met with marked financial success. Likewise, it is a source of wonder to me that with a market for pig iron considerably higher than that of Chicago the commercial experiments on the Pitt River, California, did not win out in short order.

With the work at Norway, the designers had too evidently copied slavishly the general lines of the iron blast furnace—simply substituting electrodes for tuyeres. This is as humorous as the first railway cars, which were merely remodeled stage coaches. If a man wishes to succeed in doing something new, he must depart from tradition while placing a proper valuation on the facts of tradition, and he must do his own thinking.

The designs at Pitt River and the designs of Helfenstein present an advance, but due regard must be paid to the following fundamental truth.

An electric furnace of buried arc or slag resistance type is much more efficient for melting than for reduction and smelting. *This principle is plain and obvious. Most metallurgical reactions require time for completion and to complete any reaction with a maximum of chemical or metallurgical smoothness a progressively intense application of metallurgical means must be used.*

There is a partial exception in case of reduction of zinc oxide by carbon, for both resultant bodies enter gaseous phase at once and in so passing out of sphere of activity give no chemical back pressure and accordingly reaction proceeds efficiently at a high rate. But what success the Continuous Zinc Furnace Company has had at Hartford in condensing 85 per cent of the zinc vapor to spelter while making a fusible slag, copper matte and lead bullion in one furnace and in one operation out of refractory ores, has been due in no small part to a proper recognition of this plain deduction from the laws of physical chemistry and electrothermics. And the moneys wasted in Canada, Norway, France and Germany, partly in large salaries and abortive large-scale experiments, has been due to an ignorance of physical chemistry, thus applied. Parenthetically, it can be stated that one for success must make his mistakes on a small scale.

It can be concluded, therefore, that the way to smelt iron ores electrically is to reduce iron oxides in gradual steps "seriatim" and produce a "sponge-iron" with incipient slagging of mineral impurities. This reduction can be done by combined influence of solid carbon, hydro-carbons, hydrogen and carbon monoxide.

If we have regard for J. E. Johnson, Jr.'s, principle that for each metallurgical condition there is a certain critical temperature at which the reaction velocity is zero and that each degree above that critical temperature the reaction velocity is increased; if we regard the action as going on in 100 or more elemental stages, and if we apply the foregoing to the progressive preheating and "metallizing" of the charge, imparting these heat units from some cheap source, e. g., from the combustion of soft coal, in a thermally insulated apparatus, electrical smelting of iron ores would not be so costly or so inefficient as heretofore. Such a process, if intelligently elaborated, has possibilities.

If by making a counter-current of ferruginous slag we were able to decarbonize and siliconize the iron and produce uniformly a pig iron approaching steel, eliminating progressively also phosphorus and sulphur, we might easily attain a commercial procedure of excellence. Unquestionably the only economic manner of electrically treating iron ores is to deliver an iron sponge to the smelting zone in balanced proportion.

The ultimate commercial method should follow closely the movement of an athlete in putting the shot. He starts the weight by force of muscles of leg, applies muscles of side and body next those of shoulder and arm, then of the wrist, and finally gives last impetus with a neat little "flick" of the fingers. The theory is to put in continuously muscular energy at a maximum efficiency and to increase continuously the velocity of the missile. When well done, it is the apotheosis of bodily grace.

Any metallurgical operation should conform as far as possible to a scheme like that of this analogy. This is well seen in the Hardinge conical tube mill, where the big particles of ore are hit by the large drop of large pebbles, and as size of particle is diminished, the drop and size of pebble hitting it is diminished.

With such a general procedure in mind and with firm control of product that electric smelting gives, there are possibilities of direct application of electrical heat to iron smelting that, though great, do not stretch one's imagination beyond the elastic limit.

Of course, one should never attempt to carry on a refining process where standard quality is desired, in a continuous operation. Where quantity or tonnage is desired, there should the metallurgical engineer employ a continuously acting process. When examining and studying the theory and philosophy of metallurgy some ten years ago, I discovered this fundamental principle: "That for concentration of metallurgical values, a continuous process is a necessity, while for refining an intermittent process is a necessity."

To my mind the fact that proper electro-metallurgy of iron consists in a graduated pre-heating with a final electric smelting of "metallized" product, making a "pig-steel" for subsequent short electric refining, is as clear as crystal. This opinion is based on some practical experience as well as on theory. The future will show how far this is right.

### The Electro-Metallurgy of Steel

There are three roads along which future progress will be made in applying electricity to steel metallurgy. Fortunately, we can record some pronounced commercial success in each line, and have generally recognized facts of the past and present on which to base hopes of the future; we have the evidences of things seen for existence of things unseen.

The three present roads are as follows:

(1) Crucible cast steel or alloy steel making.

(2) Steel castings in foundry.

(3) Super-refining of hot steel for "tonnage" steel in a steel plant.

In the first, unquestionably is the largest margin of profit. But an examination of the process for making "tool" steel does not disclose any great lack of satisfaction among user and maker. Much bad steel is sold as tool steel, but a great amount of fine steel is made in crucible to satisfaction of maker, vender and user.

Suppose a shop is using $100 worth of tool steel a year and doing a business of $20,000 a year. Does the manager want to hear about any new-fangled electric steel? He may have heard of some one using it with failure or he may have used it himself with ensuing trouble, and he has his daily problems. So he does not want to try new things. This is an extreme case, but it is an actual case. Now there are hundreds just like this and larger.

If we suppose that to introduce a new brand of electric steel, half a dozen and one fat-faced, strong-talking, stronger-eating salesmen were at hand, each drawing $5,000 or so per year and having a liberal expense account, could they do it in a year? "If seven maids with seven mops should sweep for seven year, do you suppose, the carpenter said, that they could sweep it clear?"

With such a premium on the importance of selling crucible steel, it is small wonder that the electric steel furnace which would present a new problem and offer in some cases only a few advantages, has made little headway.

Unquestionably, there are innate points of superiority in the electric steel furnace over the crucible. These can be enumerated as follows:

(1) Decreased labor charge.
(2) Dispensing with crucibles.
(3) Increased thermal efficiency.
(4) Control of temperature and chemical conditions.

All these can be summed up in fact that size of unit could be increased at will. Under (4) we might point out that the reaction between oxygen and carbon dissolved in steel comes slowly to equilibrium and that so-called "dead-killing" done in crucible can be effected much more easily in the electric furnace, and that a dense ingot can be better obtained by electric furnace than by crucible.

If we consider the electric steel furnace for alloy steel we see that its control over reductivity profoundly affects the commercial conditions in dealing with easily oxidized elements, as manganese, chromium, etc.

If I were going into the electric tool steel business, I would choose some special new field like the production of steel for mine drills. Here the advent of small high-speed hammer drill has brought a necessity for a better grade of steel, selling, say, for 8 cents per pound. This would give the newcomer more of an even chance, especially as the purchasers would buy in large blocks and would be guided by technical advice.

In arguing pessimistically in all the above, I disclaim any intention of doing anything but pointing out the general great commercial inertia and friction that confronts this and every similar innovation. My conviction of the gradual commercial success of the electric tool steel furnace is no less strong even if I see clearly the forces opposing it.

### Electric Steel Castings

In the steel castings we have much greater chances for an immediate broad expansion of the electric steel furnace. The economic freedom is great. For instance, in every industrial center there is a growing demand for steel castings from many consumers, and there is produced often by some people a large amount in the aggregate of steel drillings and turnings, "fins" from drop-forge bar plant, all of good chemical quality and all sold at a discount because of physical nature. Some of this contains oil enough to do all the pre-heating under which procedure the energy consumption would be reduced to 350 kilowatt hours per ton of product. Besides this there is often "off-peak" power that could be purchased from central stations for 7 mills to 9 mills.

Under such conditions it is perfectly possible to produce liquid steel suitable for castings for $26 per short ton; in fact this is an accomplished commercial fact. With a good-sized plant and especially favorable conditions it is quite probable that liquid steel could be made for $18 per short ton, and this is not the ultimate. The "baby" converter which uses a "high-silicon" low-phosphorus pig iron costing at an average of over $20 per ton has a serious rival in the electric furnace for production of smaller castings.

The quality of electric steel is high and its physical properties are such that with careful molding a higher percentage of merchantable finished castings can be expected. It must be realized that in any foundry careful planning of the molding work is a *sine qua non*, and the electric steel foundry should have ability equal to that of competing plant. Molding is at least 50 per cent. of the battle of the electric steel foundry.

We may even hazard the prediction that the open-hearth steel foundry has a potential competition in the electric furnace on large castings.

### Tonnage Electric Steel

In considering this subject we see that the legitimate hopes of the pioneers have been deferred. In apposition to this is the opposition to the electric furnace by the old-time steel men. This is a perfectly natural human feeling.

The adventurous-minded are a benefit to the community, but if all their apparently good schemes were put into effect, capital would be destroyed faster than it could be created. With the stupendous investments in rail, sheet, plate, wire, tube and shape mills it would be folly to suppose that those controlling such plants would care for a sudden change. For instance, if all structural material were made of electric steel, all the handbooks for bridge work must be revised, for in this work often 80 per cent. of the steel is put in to hold up its own weight, and if one can lighten one piece that enables one to decrease weight of a second, and so on.

Things that are in order must not be put in disorder, for progress should be orderly. In spite of all that the detractors of society say and because of what the busy workers in society do, things operate largely to the final benefit of the state and of each individual.

In the manufacture of tonnage steel it is natural to give this a first quick refining in the Bessemer or open-hearth furnace, pour the partially refined steel into the electric furnace, finish the refining there by use of a slag high in lime, allow reactions to come to equilibrium, the gases to pass off and the impurities to come to the top, and after this "dead-killing" is accomplished, to pour the metal into ladle. It was this accomplishment with the discovery of the "calcium-carbide" slag and the practicalization of the "series arc" furnace that was the second great contribution of Paul L. T. Héroult to electro-metallurgy.

This electric process has given new life to the Bessemer converter, and there are those that see a "triplex" process, Bessemerizing basic open-hearth treatment with final electric furnacing, as the process of the future. This may well be for certain large installations.

Certain it is that when operating in a large way on "duplex" process, the electric furnace can make steel of a superior quality at a cost slightly, if any, above the cost of that made by fire in a single operation. With the demand as pressing as it is now for "high-duty" steel rails, it is likely that the first marked commercial expansion in tonnage electric steel will be in the way of making a quality steel rail.

### Other Possible Application of Electrothermics in Metallurgy of Iron and Steel

These uses of the electric furnace are humble but none the less important, for they give an untrammeled chance for individual initiative. With control of heat possible by electric means and efficiency of electric furnace of "soaking-heat" type, it is not difficult to design an electric furnace for case-hardening, tempering or heat treatment that will work fairly well. To make one that is fool-proof and so have a ready sale is a commercial feat worthy of respect. But it will be accomplished.

The heating of forge bars has been tried. While, if made practical, it would be attractive, commercially considered, yet the practicalization of the forge-bar furnace is not yet done. In the analysis of its advantages we see the fact that no "scale" would be formed. This would save money, especially when expensive high-speed tool steel were used, in decreased loss and in saving on wear and tear of dies when hard oxide was removed from metal.

Electric welding has been in successful operation for years and is bound to expand.

Two more possible avenues of electrothermic advance remain. One of these is super-refining and superheating of cast iron for special castings. This has been tried and is proven to be promising and is in a measure successful.

The other avenue is the malleablizing of castings. It is not impossible to design a practical continuously acting pre-heated malleablizing electric furnace, and one so conceived and so developed intelligently, would have a definite sphere of usefulness for large-scale work.

In attacking and analyzing the problems in the electro-metallurgy of iron and steel one is amazed by the amount of work that awaits the investigator. This work is not in itself easy and the competition of older methods is hard. The rule should be to operate as Nature does, along the line of least resistance.

---

## Fiftieth Anniversary of the School of Mines of Columbia University

The celebration of the fiftieth anniversary of the School of Mines of Columbia University will begin on May 28 with a reception in the gymnasium, at which the alumni will be welcomed by the President of the University, the Dean of the School of Mines, the Senior Professor, Henry S. Munroe, the Chairman of the Celebration Committee and their wives, while the other members of the faculty and the committee and their wives will assist.

In the forenoon of May 29 there will be a big meeting in the gymnasium, at which President Nicholas Murray Butler will preside, and degrees will be given to prominent Alumni of the School of Mines. It is also expected that there will be sectional meetings of the various engineering graduates in the afternoon, with the first lecture in the Charles F. Chandler Foundation by an eminent chemist, at which Dr. Chandler, the last survivor of the founders of the School of Mines, will preside.

With the beginning of the next scholastic year, in September, will come the consummation of a plan conceived by the founders of the school, half a century ago—a graduate school of engineering—on the same footing as the other graduate schools of the University. Under the new plan three years of specialized study in the various branches of engineering will be offered, leading to the several technical degrees in the Schools of Mines, Engineering, and Chemistry. The requirements for admission to these schools will be the completion of at least three years of a college or scientific school course, including thorough instruction in mathematics, chemistry, and physics; and in addition certain courses in drafting, shopwork, surveying and mineralogy.

---

## Analysis of Natural Gas

BY W. D. BROWN

The analysis of natural gas has always been troublesome. In the methods in general use, the methane and ethane are exploded or burnt slowly with excess oxygen and the resultant decrease in volume and the carbon dioxide formed noted; from these the percentages are calculated. If but little, say, 10 c.c., of the methane and ethane are exploded with oxygen, any error in reading is multiplied many times. Again on combustion of a large quantity with oxygen, the resultant gas is nearly pure carbon dioxide and, its solubility in water varying with its percentage, a relatively large quantity is dissolved. The second contraction, i.e., on absorption of carbon dioxide being low, the result is that the sum of the methane and ethane obtained by calculation is over 100 and the nitrogen a minus quantity. To overcome these defects a method was devised in which the contraction on explosion and on absorption of the carbon dioxide is treated as one known factor, the oxygen entering into combination being the other factor. The explosion pipette, however, contains mercury covered with ¼ in. to ½ in. of water.

### Purity of Oxygen

The method as here given refers to the standard improved Orsat of the United States Steel Corporation,[1] but applies to any other apparatus equally as well. The determination of the percentage of oxygen in the commercial oxygen is made by exploding a large quantity of it with hydrogen and noting the resultant contraction, of which one-third equals the oxygen. This is best accomplished in the following manner: about 100 c.c. of pure hydrogen are forced into the burette, the capillary is filled with water from the explosion pipette, a reading is taken, and the gas forced into the explosion pipette until the water level is at 100; about 50 c.c. more hydrogen is then introduced and a reading is taken and the gas forced into the explosion pipette until the water level is at 100. About 60-65 c.c. oxygen are then added, a reading is taken and 15 c.c. portions are succesively introduced into the explosion pipette and exploded; after the final explosion, the residue is drawn over, the capillary being filled with water, and a reading is taken. One-third of the contraction is the oxygen, from which the percentage can be calculated.

### The Method

Exactly 100 c.c. of the gas are measured in the burette and carbon dioxide determined as usual by absorption in potassium hydrate. The solubility of the higher paraffins in fuming sulphuric acid inhibits its employment for the determination of ethylene in natural gas. Burrell (Bulletin No. 19, Bureau of Mines) uses a 1 per cent solution of palladium chloride as a qualitative test for ethylene. By placing the above solution in an Orsat absorption pipette it has been possible to make the test quantitative. Accordingly, the gas is passed three times through the palladium chloride solution, returned to the burette and measured; the diminution in volume represents the percentage of ethylene and any carbon monoxide or hydrogen in the gas. These gases are generally absent; however, their absence should be proven or the amount determined as shown later. One-half the residue is then discarded and the remaining half passed into the phosphorus pipette for the absorption of any oxygen in the gas originally or through error in sampling. While the oxygen is being absorbed in the phosphorus pipette about 130 c.c. of nearly pure oxygen are measured and transferred to the explosion pipette. This is done in the following manner: nearly 100 c.c. of oxygen are forced into the burette, the capillary is filled with water from the explosion pipette, a reading is taken, and the gas forced into the explosion pipette until the water level is at 100, the capillary being full of oxygen; about 30 c.c. more of oxygen are now forced into the burette, a reading is taken, and the gas is forced into the explosion pipette, the capillary being filled with water from the burette. The gas in the phosphorus pipette is then drawn into the burette and measured, the oxygen being thus determined. About 10 c.c. of the gas are then forced into the explosion pipette and exploded. This is repeated until all the gas has been exploded, care being taken that the last portion is well mixed before the explosion. The resultant gas is then forced to bubble through the potassium hydroxide solution and finally is transferred to the burette, the capillary filled with water, and a reading taken. The sum of the impure oxygen added and the residue exploded minus the residue after absorption of carbon dioxide is contraction "A"; or, the difference between the last two readings plus the impure oxygen added equals "A." Hydrogen is then added to the capacity of the burette and the mixture exploded and the contraction "C" noted.

---

[1] This Journal, IX, 302.

From the above contractions ("A" and "C") and from a knowledge of the amount of oxygen in the commercial oxygen, the methane, ethane, and nitrogen may be calculated, the absence of hydrogen and carbon monoxide being assumed for the time.

The reactions of burning methane and ethane are as follows:

$$CH_4 + 2\,O_2 = CO_2 + 2\,H_2O$$
$$2\,C_2H_6 + 7\,O_2 = 4\,CO_2 + 6\,H_2O.$$

From these it is seen that the total contraction on combustion and absorption of methane and ethane are 3 and 9/2 times the volume of the respective gases; or that "A" $= 3\,CH_4 + 9/2\,C_2H_6$. Likewise the oxygen consumed (Oc) is 2 and 7/2 times the volumes of the respective gases; or $Oc = 2\,CH_4 + 7/2\,C_2H_6$. Also it is clear that the oxygen consumed equals the oxygen added (Oa) minus the oxygen entering the second explosion, which is 1/3 C or $Oc = Oa - 1/3\,C$.

From these equations the following are derived:

$$CH_4 = 7/3\,A + C - 3\,Oa$$
$$C_2H_6 = (A + 1/3\,C - Oa) - CH_4$$
$$N_2 = \text{residue exploded} - (A + 1/3\,C - Oa).$$

*Example—Data.*

### Burette Readings

PURITY OF OXYGEN

| | | |
|---|---|---|
| Hydrogen added | 1.0 | 99.0 |
| Hydrogen added | 48.2 | 51.8 |
| | | 150.8 |
| Impure oxygen added | 38.2 | 61.8 |
| | | 212.6 |
| Explosion | 68.0 | 32.0 |
| | | 180.6 Contraction |
| | | 60.2 |

60.2 ÷ 61.8 = 97.4% oxygen in commercial oxygen.

GAS ANALYSIS

| | | |
|---|---|---|
| Gas measured | 0.0 | |
| Potassium hydroxide | 0.2 | 0.2 carbon dioxide. |
| Palladium chloride | 0.6 | 0.4 ethylene. |
| | 99.4 | |
| | 49.7 | |
| | 50.3 | |
| Stick phosphorus | 50.3 | 0.0 oxygen. |
| Impure oxygen | 0.6 | 99.4 oxygen. |
| Impure oxygen | 66.3 | 33.7 133.1 = 129.64 c.c. pure $O_2$ added. |
| Explosion and absorption | 77.4 — 50.3 = | 27.1 |
| | | 160.2 = contraction "A." |
| Hydrogen added | 9.7 | |
| Explosion | 63.7 | 54.0 = contraction "C." |

CALCULATIONS

7/3 of 160.2 + 54.0 — (3 × 129.64) = 38.9 = methane
(160.2 + ⅓ of 54.0 — 129.64) — 38.9 = 9.66 = ethane
49.7 — (160.2 + ⅓ of 54.0 — 129.64) = 1.14 = nitrogen

| | |
|---|---|
| Carbon dioxide ($CO_2$) | 0.2 |
| Illuminants ($C_2H_4$) | 0.4 |
| Oxygen ($O_2$) | 0.0 |
| Carbon monoxide (CO) | 0.0 |
| Methane ($CH_4$) | 77.8 |
| Hydrogen ($H_2$) | 0.0 |
| Nitrogen ($N_2$) | 2.3 |
| Ethane ($C_2H_6$) | 19.3 |

### Calorific Value

An average of the values for ethane given by Berthelot, Guldner, Thomsen, and Payne is 1760 B.t.u. per cubic foot dry gas at 62 deg. Fahr. and 30 in. mercury for the gross. The net is found by subtracting from the gross, 150 B.t.u., a value obtained from the tables of Marks and Davis. The net is then 1610 B.t.u. The net B.t.u. of methane and ethylene is 912 and 1491 respectively. The calorific value of the gas cited is then 1026 B.t.u. net. In general the gross is found by adding 1/2 $(H_2 + 2\,CH_4 + 2\,C_2H_4 - 3\,C_2H_6)$ to the net.

### Determination of Hydrogen and Carbon Monoxide

The absence of these gases was assumed in the preceding method. It is advisable to prove their absence or to determine their percentage. For this purpose, the supply of hydrogen is disconnected and a palladium tube connected to the end of the apparatus, the other end of the palladium tube is connected to an absorption pipette containing water. The palladium tube is immersed in a beaker of water at 90-100 deg. C. and oxygen passed through the tube to oxidize any hydrogen present. The water is drawn to a specified point on the absorption pipette and the capillary tube of the apparatus filled with water from the explosion pipette. Fifty c.c. of natural gas are then introduced into the burette and measured, and the carbon dioxide, ethylene, and oxygen removed as usual. About 10 c.c. of oxygen are then added and a reading taken. The gases are then passed back and forth through the palladium tube, which is immersed in hot water at first and then in cold water to cool the gas. The gas is finally brought back into the burette, the water in the pipette being at the previous level, and a reading taken. The diminution in volume is noted as contraction a. The gases are then passed into potassium hydroxide, drawn back and measured; the dimunition in volume is contraction b.

From a study of the contractions formed in the combustion of carbon monoxide and hydrogen it is seen that

$$CO = b$$
$$H_2 = \frac{2\,a - b}{3}$$

If a contraction has been found here, denoting the presence of hydrogen and carbon monoxide, or either, these contractions would have occurred in the determination of methane and ethane by explosion. In this case the sum of "a" and "b" must be deducted from contraction "A" and added to contraction "C."

Duquesne Works, Carnegie Steel Co.

---

**Coarse Crushing Plant of Utah Copper Co.**—The redesigned coarse crushing plant at the Magna plant of the Utah Copper Company, where 16,000 tons of ore are daily handled, is the subject of a profusely illustrated article in No. 63 of the Labor Saver, published by the Stephens-Adamson Mfg. Co., of Aurora, Ill. The entire volume of ore was formerly handled by an extensive system of cars, carrying from the bins to the crushers and thence to the reduction mill. The most important feature of the new design is the extensive use of Stephens-Adamson apron feeders and belt conveyors. The redesign is stated to have resulted in great savings.

## Radium Hearing at Washington

*[Editorial Correspondence]*

In our last issue we gave a statement of the federal-state controversy over the proposed conservation of radium-bearing ores in the United States, and showed particularly the attitude of the Secretary of the Interior and his desire to prospect for, mine and treat such ores under federal direction. Since that writing, and in deference to the protest raised by Colorado miners and prospectors, state authorities and companies interested in producing radium, the House committee on mines held a hearing in Washington, at which it sought to get full and complete information on the status of radium industry in this country. All interested parties were heard, and the record has been published.

Much of the record must be classified as light reading; it will be appreciated only by those who have a knowledge of the facts plus a saving sense of humor. There were, however, some matters introduced that will be of interest because they officially enlighten the public on points that formerly were matters of conjecture, rumor or personal opinion.

The gist of the testimony of the opponents of the federal plan of development was a fundamental objection to interference by the United States in the exploitation of the radium-bearing ores and a belief that such deposits would be best and most quickly developed by private enterprise. A point not brought out, but which is worthy of consideration, is that if the government engages in the metallurgy of radium and publishes its methods of operation, patentees of similar processes, who have devoted their time and money to the discovery of suitable methods of treatment, may be deprived of the benefits of their work. Having sought and secured the protection which a patent is assumed to offer, they may find it difficult, if not impossible, to gain the rewards to which they are entitled by their ability and energy. This complaint against government operation in the radium industry is probably worth more than most of the objections brought out at the hearing.

### The Government and the National Radium Institute

It developed early in the hearing that there was a misunderstanding regarding the relations existing between the government and the National Radium Institute. The latter is financed by Dr. James Douglas and Dr. Howard A. Kelly, who have completed a plant at Denver for the treatment of carnotite. At the hearing the motives of these gentlemen were impugned and their action was characterized as mercenary. This resulted in making public the following letter from Dr. Kelly to the Bureau of Mines, stating the terms on which a cooperative arrangement was sought and secured.

New York, October 7, 1913.

*The Director, Bureau of Mines.*

Sir: The National Radium Institute (Inc.) is a corporation duly organized and existing under and by virtue of the laws of the state of Delaware and is interested in the study of the best methods of producing uranium, vanadium and radium, and in the mining and concentration of ores from which these products may be obtained for use in radium therapy. It is interested in certain carnotite and other suitable ores mined in Colorado from which those products are obtainable.

For the benefit of the people and to secure the advantage of a scientific and technologic study of efficient methods of production, as well as mining and concentration of the ores, without waste, the institute solicits the co-operation of your bureau—that is, the services, under your supervision, of enough chemists and mineral technologists connected with your bureau as may be necessary for the proper technical control and supervision of the mining and concentration of carnotite and other suitable Colorado ores, in the study of the methods outlined and generally in the prosecution of the investigation contemplated, the results to be published by you.

To aid in such work, the institute will furnish the sum of $150,000, to be available as follows, and to be expended after consultation with us as you advise: $70,000 during the year ending August 30, 1914 · $40,000 during the year ending August 30, 1915, and $10,000 during the year ending August 30, 1916, it being estimated that about three years are required for the exhaustive investigation that is desired. The funds received from the sale of any by-products other than radium belong to us, and may also be used in the prosection of this work. It is proposed to expend this money in the mining of the carnotite or other suitable ores, to an amount of 1000 tons, more or less, of high-grade ore (over 2 per cent), or in the purchase of such ores as are necessary to an adequate study of the subject, and in the establishment and operation of a plant for the working up of said ores; also in the erection and operation of a small concentration plant for the treatment of any low-grade ore (less than 2 per cent $U_3O_8$) as may be mined or purchased, and, of course, in the payment of necessary wages of the plant operatives.

The institute also is entirely willing that any radium produced in excess of 7 grams of anhydrous radium bromide ($RaBr_2$) from any 1000 tons of carnotite ore may be donated to the bureau for further experiment or study.

As the institute has already on hand 100 tons (more or less) of carnotite, it is made a condition of this offer that this ore be first extracted far enough to demonstrate to the satisfaction of the institute the practicability of the processes employed.

Until this is done no more than $5,000 shall be expended on mining or concentration.

At the completion of this demonstration, the undersigned may withdraw from this project, and shall not thereafter be liable for any further expenditures of money other than sufficient to take up all obligations incurred up to the time of the said withdrawal, and no further demands on account of said $150,000 shall be made. All expense incurred in said transactions shall in any event be on account of said $150,000.

The institute would esteem it a favor if its co-operation should be recognized on the cover and title page of any published report of the results of this investigation.

If this proposition is acceptable, will you not kindly advise the institute as soon as you conveniently can?

Respectfully,
National Radium Institute (Inc.),
By Howard A. Kelly, *President.*

*Attest:*
Archibald Douglas, *Secretary.*

In addition to this letter, the Secretary of the Interior also introduced telegrams from Drs. Douglas and Kelly, stating that they were willing to make gratuitous transfer of the Institute's plant to the government on the termination of the three-year agreement.

The Secretary also reiterated the governmnt's intention to develop the radium industry at the earliest possible moment, and not retard it in any way nor lock up the resources of the states. His plan involved the withdrawal of some 10,000 square miles of land in Colorado and Utah, dividing this into 320-acre tracts and giving a prospector the exclusive right to search for radium-baring ores on such a tract, and to protect him in any discoveries. If ore was developed and mined the government might either receive a part or all of it for treatment, allowing the balance, if any, to reach the commercial market. No present holdings would be affected, while new prospecting would be stimulated and a domestic market assured.

### The House Radium Bill

As a result of the hearing a compromise bill has been introduced in the House. The original idea involved withdrawal and a leasing system, but this has been abandoned in an effort to harmonize the various interests. At the time of writing another hearing is in progress before a Senate committee, but it is expected that the results will not materially affect the present status, and that a bill similar to the following will be passed.

A BILL

To provide for and encourage the prospecting, mining and treatment of radium-bearing ores in lands belonging to the United States for the purpose of securing an adequate supply of radium for Government and other hospitals in the United States, and for other purposes.

*Be it enacted by the Senate and House of Representatives of the United States of America in Congress Assembled*, That all deposits of carnotite, pitchblende, or other ores, containing radium in sufficient quantity for extraction, in lands belonging to the United States, and the lands containing the same, shall be subject to exploration, occupation and purchase under the mining laws upon condition that said radium-bearing ores shall be exclusively sold and delivered to the United States as hereinafter provided, and all said ores hereafter mined from lands the title to which is now in the United States, and which were not located under the mining laws of the United States, and of the States wherein the same are situated prior to the fifteenth of January, 1914, shall be so sold and delivered, and the exclusive right of the United States to purchase and receive said ores from the owners of such lands, their lessees and assigns, together with the right of the United States to annul and void any patent issued for such lands because of failure to develop and mine such ores with reasonable diligence, shall be expressly reserved in any and all patents which may hereafter be issued.

Sec. 2. That the locators of lands containing said deposits of radium-bearing ores shall prospect, mine and develop such deposits continuously and in good faith, and failure to prosecute such prospecting, mining and development on lands chiefly valuable for said deposits for a consecutive period of four months in any calendar year shall subject the same to relocation, or in the absence of relocation, to the forfeiture at the discretion of the Secretary of the Interior: *Provided*, That the Secretary of the Interior shall have authority by public notice to suspend for such period as he may fix the requirement of continuous development as hereinbefore provided.

Sec. 3. That the sale, gift or other disposition of said radium-bearing ores to any person, association or corporation other than the United States shall be unlawful, and any violation hereof shall subject any location made or patent issued to forfeiture, and the person, association or corporation so selling, giving or otherwise unlawfully disposing of said ores shall, upon conviction thereof, be punished by a fine of not less than twice the value of the ores so sold, given away or unlawfully disposed of: *Provided*, That when in the opinion of the Secretary of the Interior special conditions arise which make such action necessary he may, by special order, permit the sale and delivery of said ores after or without tender to the United States, as he may deem advisable.

Sec. 4. That the Secretary of the Interior be, and he is hereby, authorized to erect, maintain and operate a plant or plants for the concentration and treatment of radium-bearing ores and the extraction of the radium and by-products therefrom; to purchase radium-bearing ores mined from lands occupied and held under the provisions of this Act at such prices, to be fixed by him from time to time and published in advance on the first day of January and July in each year, as will insure the prospecting for and mining of such ores, and, if need arises, to purchase or accept radium-bearing ores from other sources; to sell the by-products of such ores at the best prices obtainable; and he shall make such disposition or use of the radium produced as will best serve the need of the people of the United States.

Sec. 5. That the Secretary of the Interior shall report to Congress at the beginning of each regular session all receipts, expenditures and operations under the provisions of this Act, with such recommendations concerning future operations as he shall deem proper. All mining operations on lands located as herein provided for shall at all times be subject to inspection by authorized representatives of the Secretary of the Interior, and the locators or patentees of such lands, their lessees and assigns, shall transmit monthly to the Secretary of the Interior or to his authorized representative a statement of all developments, the nature thereof and the quantity of ore mined.

Sec. 6. That there is hereby authorized for the erection and general equipment of a suitable building or buildings for the radium extraction and other work of the Bureau of Mines in the metal mining States the sum of $150,000, and for the necessary expenses connected with the purchase and treatment of radium-bearing ores and the extraction of radium therefrom during the fiscal year ending June 30, 1915, the further sum of $300,000.

---

**Sight-Flow Indicator.**—Bulletin 57, "The Phenix Sight Flow Indicator," recently issued by The Richardson-Phenix Co., of Milwaukee, Wis., illustrates and describes how this little device can be inserted in any pipe line carrying a liquid, such as water lines of water-cooled transformers and the supply pipes of water jackets of gas engines and air compressors, and how it shows at a glance or indicates electrically by lighting a lamp or ringing a bell when the flow of liquid is interrupted. Several recent improvements in the Sight-Flow Indicator are also described, making it now possible to adjust the indicator so that it will give an alarm before the liquid stops flowing entirely, that is, when the speed drops to some pretermined minimum. This improvement has made it especially suitable for use on water-cooled transformers.

**Pickling Machines.**—Bulletin M of the Mesta Machine Company, of Pittsburgh, Pa., entitled "Mesta Improved Pickling Machines," describes these machines which have several interesting, novel features. The first is that mechanical action is brought into play to such an extent that the material is pickled with about one-half of the acid and labor required in hand-pickling. For this purpose the material to be cleaned is moved through the acid with a predetermined velocity and a slight jar at the end of each down stroke. If sheets are pickled, the jarring action at the end of the stroke separates and shifts the sheets sufficiently to allow the acid to enter between them and to prevent their sticking together. The acid washing over the surfaces has, in conjunction with the loosened particles, a scouring action which thoroughly cleans the sheets. The uniform action of the acid upon the surfaces is assisted by the thoroughness of the agitation, which does not allow acid layers of different density to form.

**The Buffalo Forge Company** has opened offices at 176 Federal Street, Boston, Mass., for its fan, ventilating and pump departments, being represented in the New England territory by Mr. B. R. Andrews, formerly with the B. F. Sturtevant Company.

# The Boiler Plant of the Blast Furnace

BY J. E. JOHNSON, JR.

In the early days of blast furnaces when tonnages were small and the quantity of iron made per cubic foot of furnace capacity was also very small as compared with present practice, the quantity of power required to drive the furnace was relatively insignificant. But even in that early day it was so considerable that plants were generally located with reference to a water power site, the gases from the top of the furnace being allowed to burn to waste in the air.

With increase in size and rate of driving, the amount of power required increased very rapidly. We shall see in a later article that this increases nearly as the square of the output of a given furnace, and that modern furnaces require from 2000 to 3000 horsepower to drive them. Consequently as furnaces were driven harder it became more and more difficult to find water power adequate to drive them. This, with the increasing introduction of the steam engine in suitable sizes and designs, and the increasing realization of the vast fuel value of the furnace gases, led to the introduction of steam power for blowing furnaces.

This step was hastened by the advent of anthracite as a furnace fuel, the pressures required with it being so much greater than they are with charcoal fuel in a given size furnace, and under similar conditions in other respects.

The question of the quantity of furnace gas per ton of iron produced and its heating value will be treated at some length in a later article, but in tracing the development of the present subject we may say that in ordinary, good modern practice about one-half of the total thermal value of the fuel charged comes out of the top of the furnace in the form of its top gases. Some 10 or 15 per cent of this heat is in the sensible condition, the rest is contained in the gas in the shape of CO, whose combustion with air gives 4370 B.t.u. per pound of CO, or 10,200 B.t.u. per pound of carbon contained.

In good modern practice there are in the average produced about 140,000 to 200,000 cu. ft. of gas, of which about 60 per cent by volume is nitrogen, and the remaining 40 per cent is made up of CO, $CO_2$ and hydrogen in varying quantities; this gas contains from 90 to 115 B.t.u. per cubic foot.

In Lake ore practice the quantity used is from 140,000 to 160,000 cu. ft. per ton of iron; the analysis approximates N 60%, $CO_2$ 15%, CO 23%, $H_2$ 2%, and the heating value 95 B.t.u. per cubic foot.

In districts where leaner ores are used and correspondingly more coke is required the percentage of nitrogen does not alter much but the CO increases at the expense of the $CO_2$ with proportional enrichment of the gas and increase in its thermal value.

In the early furnaces, and in a few cold blast charcoal furnaces to this day, this gas was allowed to escape freely from the top of the furnace, from which it burned continuously in a great flame, visible for miles at night.

The first attempts to utilize this heat for heating the blast and for raising steam were made by setting hot-blast stoves and boilers at or near the level of the furnace top, building a masonry flue completely around the top of the furnace with ports leading from the furnace top into this flue, and a powerful chimney at the far end of the combination. This chimney drew the gas, mixed with air, through the ports into the flue and thence into the boilers and hot-blast stoves. The mixture of gas and air was, of course, made at the furnace top, and so only flame was drawn through the flues.

At a later day the top of the furnace was closed by a huge inward opening valve, universally called the "bell," consisting of a cone, generally with a slope of about 45 deg., turned true in its lower portion and fitting against a similarly turned seat on the bottom of the "hopper," which in turn made a tight joint with the furnace lining, or in later times, with the shell.

All this will be described at length in dealing with the furnace top; suffice it for our present purpose to say that the charge in several portions is dumped into the hopper and rests in the bell which normally is kept closed when the charge is completed, the bell is opened long enough to allow the charge to slide into the furnace, and immediately closed. The total period during which it is open is seldom or never 5 per cent of the total time. and it is only during this period that the gas has an opportunity to escape, the remaining 95 per cent of the gas being confined and forced through the ports at the top of the furnace into the brick-lined pipes which take it to the points of consumption. In this case the furnace is kept practically air-tight, and the pressure of the gas is always somewhat greater than that of the atmosphere, to overcome resistance offered to its passage by the gas pipes, consequently when the bell is opened air does not flow in but gas flows out. As a result air never, in proper operation, enters the top of the furnace, and as the gas contains no oxygen it is perfectly non-combustible in the absence of air.

In this system, therefore, the mains carry not flame but gas, which may even be reduced to atmospheric temperature and still remain an excellent combustible.

Under these conditions the gas can be led without difficulty to very considerable distances and consequently the stoves and boilers can be located with reference to other considerations. They have accordingly, for many years past, been placed on the ground and in positions best suiting the convenience of the plant as a whole.

This gas containing, as has been said, roughly 50 per cent of the total energy of the fuel charged, supplies the heat necessary for all the operations around the plant outside the furnace itself. Its first and foremost use is for the purpose of heating the air, with which we have no present concern. This, in good practice, consumes about 40 per cent of the total gas. In first-class modern practice another 10 per cent is required for blowing power, and 5 per cent for miscellaneous purposes around the furnace, hoisting, pumping water etc., leaving 45 per cent of the gas, or nearly 25 per cent of the total energy of the fuel charged available for purposes entirely separate from the furnace.

The steam plant at the blast furnace has been until very recent years a poor and inefficient one, measured by the standards prevailing at similar periods in other lines of industry. The reason for this is not far to seek. When the closed-top furnace was introduced, and it was found that the gas could be forced by this means to any desired point within reason, it soon developed that the furnace possessed a source of power ample for its needs, even with the cheapest and simplest type of steam plant.

Steel mills at that early day were not generally built immediately in conjunction with furnace plants as they are today, and the latter, therefore, did not have in general any local market for the surplus power, and until the general introduction of electricity for lighting and power transmission there was no disposition for power except such as could be developed immediately where it was to be consumed. Hence there was no use for surplus power which might be developed by the use of economical machinery, and as this machinery was higher in first cost, and more expensive to operate than the simplest and plainest type, the latter was in almost universal use until within the last fifteen or twenty years. Slide-valve or piston-valve engines with late cut-off and little expansion, using low boiler pressure and, non-condensing, were the rule.

The boilers likewise were of the cheapest, simplest and generally most inefficient types. Plain cylinder boilers with their enormous settings and proportionately enormous air leakage were the prevailing style until within the last twenty or thirty years. These boilers were literally plain cylinders, sometimes a pair set side by side, from 3 to 4 feet in diameter and 40 to 50 feet long, entirely without flues. Sometimes there were two pairs, one above the other, the lower one joined to the one vertically above it by necks on each outside or "high" sheet, the whole suspended from two or three suspension points and exposed to the flame up to a height just below the water level in the upper cylinder, the gases making only one pass straight through to the chimney connection.

On account of their enormous water contents in comparison with their heating surface, these boilers possessed a great quantity of preserved energy, and steam pressure would not drop injuriously during a few minutes suspension of the gas supply. They were also very easy to clean because containing no tubes. Men could be put inside them and chip off the scale with chisels or with axes which, of course, is impossible in other types of boilers except as to a small fraction of their heating surface.

Other than this these old types of boilers had little to recommend them, as the great cost of the setting and the high price per square foot of their heating surface made their cost per horsepower installed about as high as that of better types.

The great increase in the tonnage of iron produced in a furnace of a given size, which might almost be said to have culminated with the Duquesne revolution, and the increase in the size of the furnaces themselves, both acted in the same direction, that of requiring a higher blast-pressure to force the desired quantity of blast into the furnace. This in turn required more power, and, therefore the practice which had been adequate if not ample for the old conditions became inadequate for the new because its consumption of steam was so great that the combustion of the furnace gas available was frequently unable to supply the quantity required. When this occurred it was necessary to burn coal under the boilers, and such coal represented a dead loss to the operation.

During the same period the integration of iron and steel plants developed extensively. Furnaces were built at large steel plants, or steel plants at furnaces in order that direct metal from the furnace might be used at the steel plant with a great saving in expense for both, the furnace sending the iron in ladles to the steel plant and so avoiding the cost of casting and handling it, while the steel plant avoided the greater cost of remelting it.

The well-equipped furnace plant having generally if not always, a considerable excess of steam at its command, advantage was taken of this fact by running a steam pipe from the furnace boilers to the steam mains at the steel mill, the latter using enormous quantities of power, but having no source of supply of its own except by burning coal or other commercial fuel.

The great value of the power so supplied became more and more appreciated and the power plant at the blast furnace was gradually improved so as to leave a larger margin of gas available for the steel mill, and this process has now gone on until some of the finest and most economical power plants in the world are those employed in blowing blast furnaces, while the subject of power development for this purpose has enlisted closest attention in Europe as well as more recently in this country.

It is a rather interesting fact that this gradual progress from the utter indifference which came from having a prodigal supply of power and no use for the surplus, to the present condition in which the expenditure of every thermal unit is watched with a jealous eye, occurred simultaneously with the development of the steam boiler from the relatively crude types, which I have described, and which were in practically universal use at one time in all other industries as well as at the blast furnace, into the modern water-tube types. First came the single-flue and two-flue boilers, then through a gradual increase in the number and decrease in the size of the flues, the multitubular boiler, which was for so many years the standard in good steam practice. Then came the later evolution, forced by rising steam pressures from the horizontal tubular boiler to the water-tube boiler, which became well established about the time the demand for more economical boilers for blast furnaces developed.

In this way blast furnaces skipped that period of development during which the horizontal tubular reigned supreme in most industries, and passed immediately from the cruder types to the modern water-tube boiler.

### Horizontal Tubular Boilers

At the Illinois Steel Works in South Chicago, where coal was expensive as compared with Pittsburgh, and where a furnace plant and steel mill were early operated in conjunction, they used at one time a great number of horizontal tubular boilers; but this is the only large blast-furnace plant, to my knowledge, where extensive use was ever made of this type of boiler. These have now all been superseded by water-tube boilers.

In New England, where fuel is expensive and where the textile mills use in the aggregate almost as much power as do the steel mills of the country so that their operators have been forced to use every possible economy in steam generation and utilization, they continue to use the horizontal tubular boiler to a great extent, even down to the present time.

It is, therefore, not on the ground of economy that this boiler has been driven out, but rather by two demands of modern practice which jointly have set conditions impossible for it to meet. These two conditions are, first, increasing steam pressure; second, a demand for large individual units so as to keep down as low as possible the total number of units for large powers. Both these conditions require heavier shells for horizontal tubular boilers, and these being exposed to the direct action of the fire their safe thickness is limited to that which will permit the cooling effect on the inside to prevent the rapid burning or cutting away of the outside, particularly at the seam with its double thickness and projecting rivets.

Water cooling is effective against the direct action of fire only within certain definite limits of thickness, and these are approximately reached in the horizontal tubular boiler at a capacity of 300 horsepower and a pressure of 125 lb. to the square inch, and though by special construction these conditions have been exceeded in horizontal tubular boilers of this type, this pressure is lower than that demanded by modern practice, and the units are smaller than is desirable in large plants. Hence the horizontal tubular boiler is eliminated from the competition.

Moreover, the question of safety is always to be considered, and while it is by no means to be thought that water-tube boilers are free from accidents, it must be admitted that the consequences of such accidents are probably on the average less destructive to life and property than those of horizontal tubular boilers.

### Types of Water-Tube Boilers

The number of types of water-tube boilers which have been introduced in the last twenty or thirty years is literally legion. Many, if not most of them, have been applied from time to time and from place to place, in blast-furnace service. Many of them are still in such service. But the development of modern plants has settled down to the use of half a dozen types, of which we may consider four.

Before proceeding to a description of these, however, a general review of the conditions of operation of boilers at blast furnace plants will not be amiss. These differ in some respects from those prevailing in ordinary insallations. First, they are normally gas-fired, though provision is always made for the use of coal should it become necessary. Second, the furnace gas with which they are fired generally contains a considerable quantity of dust which settles on the tubes and heating surfaces, and rapidly impairs their conducting power, if not removed. Third, the boilers are operated twenty-four hours a day and seven days a week. There is no stoppage of the plant over Sunday as is customary in other industries during which the boilers can be cleaned, and for this reason a sufficient reserve of boiler power must be installed to allow at least one unit to be constantly out of service for cleaning. Other than these, the conditions do not differ materially from those of economical boiler operation in general.

### General Considerations Concerning Water-Tube Boilers

The first and most important condition is, of course, that the tubes must be kept clean, not only externally but internally, and until very recent years it was practically impossible to do this in any except perfectly straight tubes. This is no longer true, but at the same time straight tubes are greatly to be preferred to curved ones, as they are less expensive and generally far less troublesome to replace than curved tubes, and in everything except length are interchangeable, which cannot be the case when curved tubes are used.

Owing to the nature of hydrostatic pressure, any vessel subject to such pressure tends to become circular, and if any other form than this is used in order to resist deformation it must be given greater strength than would be required by the circular form in a proportion greater than its deviation from the latter. For this reason flat, parallel surfaces on upper and lower drums, until recently the only ones between which straight tubes could pass, have been frowned upon by boiler insurance companies and boiler inspectors, particularly during recent years when pressures have risen far beyond what they were ten years ago, because of the difficulty of staying such flat surfaces so that they will stay flat, and the liability to excessive stresses and leakage, and even failure if they distort under pressure.

Moreover, it was for a long time very desirable to have the tubes not only straight, but to have them so set that their ends could be exposed and a cleaner carried by a rigid rod a little longer than the tube, inserted and driven through. This could not be done if the tubes were set in drums, because the drum would prevent the entrance of a cleaner so mounted into the tube. Therefore, two of the most successful of the earlier types of boilers had parallel water legs depending from opposite ends of a combined steam and water drum above, and from one of these water legs to the other ran the straight tubes. The water legs could obviously not be circular in shape and yet permit the use of straight tubes, so they were made in various ways to give the necessary strength and access to the tube ends, and at the same time permit the use of straight tubes.

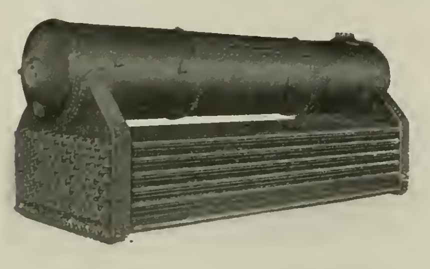


FIG. 1—THE HEINE BOILER WITHOUT ITS SETTING

One of the types of boilers on this general plan is the "Heine," built by the Heine Safety Boiler Company, and illustrated in Figs. 1 and 2. Fig. 1 shows the construction of the boiler independent of its setting. The water legs are made of flat plates stayed together by screw stays, as in locomotive-boiler construction, the perfectly flat parallel surfaces lending themselves to safe and adequate staying better than any other shape. The inner surfaces of the water legs act as the tube sheets, while holes a trifle larger than the tubes are cut through the outer surface of the water legs exactly in line with these. These outer holes are closed when the boiler is in operation with a hand-hole plate, dog and bolt, but when the tubes are to be cleaned or removed these hand-hole plates are removed and give free access to the ends of the tubes.

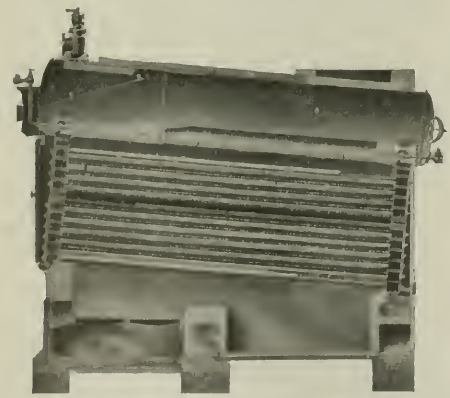


FIG. 2—THE HEINE BOILER IN ITS SETTING

The screw stays should be called stay tubes and not stay bolts, because each of them contains a hole large enough to permit the entrance of a half-inch pipe with a steam jet on the end, and as these stay-tubes are in the center of the space between the water tubes this permits the steam jet to pass down between the latter from end to end, and thus effectively blow the dust off one-fourth of each of the four surrounding the space.

This is necessary with boilers in all industries, but is particularly necessary at blast furnaces because of the great quantity of fine dust carried by the gas at the majority of plants.

The boiler in its setting is shown in Fig. 2, which also shows the baffling. It will be seen that the gases go to the rear, then to the front, and then to the rear again, passing around the drum on their way to the stack. For this reason the drum is covered with fire brick above the water line, and this is very important because I have seen the drums of this type of boiler badly burnt through failure to keep these covering bricks in place.

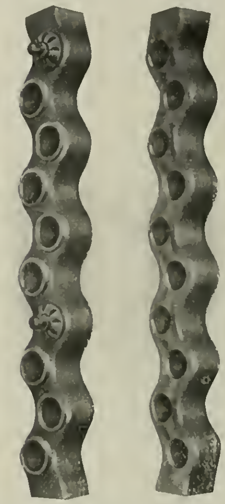


FIG. 3—WROUGHT STEEL INCLINED HEADER

Fig. 2 shows a boiler adapted only for the burning of coal, but only two minor changes are required to adapt it to burning furnace gas also. First, it should be set a little higher above the grate, and a burner opening should be provided through the front wall between the bottom of the water leg and the top of the fire arch. Second, the tiles used as baffling immediately over the fire should be of the type which completely surrounds the tubes, covering their lower as well as their upper surface, as such tiling constitutes a water-cooled fire arch. The tiles become hot enough to permit combustion, whereas the relatively cold tubes kill down the flame before the gas and air have a chance to mix sufficiently to produce complete combustion. When such gas has once been extinguished it will not reignite, but passes out of the stack unburnt and represents a dead loss.

### The Babcock & Wilcox Boiler

This boiler differs from the Heine principally in having the water leg subdivided into as many sections as there are vertical rows of tubes, this being a still further extension of the sectional idea for localizing and minimizing the effect of failure of any part. As the arrangement of the tubes in a vertical plane is staggered these headers are made sinuous, as shown in Fig. 3.

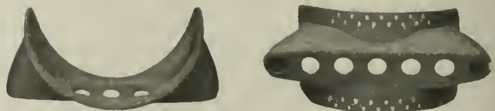


FIG. 4—FORGED STEEL CROSS BOX

Each of these headers is connected to a saddle or cross-box riveted to the drum, by means of straight tubes expanded into the top of the header at one end and into the bottom of the cross-box at the other. The cross-boxes are shown by Fig. 4.

The boiler as a whole is well shown by Fig. 5. This boiler is suspended from a structural steel frame instead of being supported directly on the brick, as is the case in the Heine boiler. Another difference from the latter boiler is that in this case the passes are at right angles to the line of the tubes instead of parallel with them.

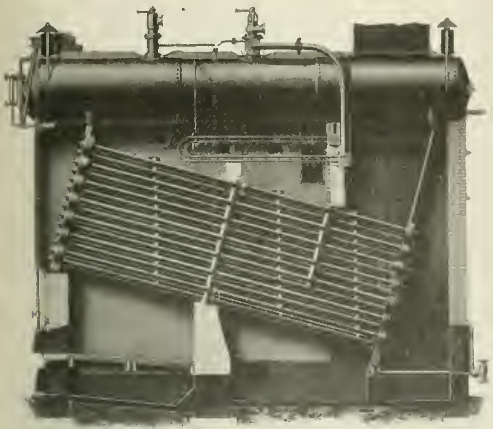


FIG. 5—BABCOCK & WILCOX BOILER IN SETTING

The baffles are built up of fire brick supported by clamps around the tubes. These fire bricks make a continuous wall with the tubes passing through it, and supporting it. One of these walls run up from the lower bridge wall, the other comes down from the suspended upper bridge wall, the passage of the gases being first up, then down, and then up again, either out above, or through the suspension tubes of the rear headers, and into an underground flue.

The arrangement of having the gas pass off upward is very much to be preferred to that in which it passes downward because the latter involves the use of underground flues, and when these become obstructed by dust as they ordinarily do in the course of a few months run, they can in general only be cleaned by shutting down the plant and putting men into them to shovel them out. In some cases the arrangement is such that a heavy stream of water can be turned into the flue and the dust washed out with this, but even this arrangement is inferior to the overhead flue, which can be provided with dust pockets through which the dust can be drawn into carts or wheelbarrows before it accumulates to an objectionable extent, and without any interruption to operation.

The boiler here shown is equipped with a superheater, this being the U-shaped coil lying on its side in the space between the bottom of the drum and the top of the water tubes. Super-heaters, as far as I know, have never ben used in blast-furnace practice, probably for the reason that they have the reputation of requiring a good deal of maintenance, and a correspondingly large number of interruptions to service, both of which would go far to offset any advantage they might produce in steam economy, interruptions to continuous service being particularly objectionable.

These boilers can be arranged for a gas firing exactly as described for the Heine, by the introduction of a gas burner immediately above the fire door, but my preference is strongly in favor of the use of a combustion chamber for burning furnace gas, and as the tiles surrounding the tubes cannot be used in this boiler because they would cut off the passage of the gas and flame completely, I am strongly in favor of the use of a Dutch oven in front of these boilers when they are to be fired with furnace gas.

Such a Dutch oven will be described and illustrated in connection with the Rust boiler, and, therefore, need not be described in detail here. In order to apply it successfully the boiler generally requires to be set somewhat higher than when no Dutch oven is used, but this is a matter of slight cost and no subsequent disadvantage.

The sinuous headers fit into each other very closely and no opportunity is permitted to introduce a steam jet longitudinally between the tubes. Consequently, in order to permit these boilers to be blown off three sets of blow-off doors are provided whose location is indicated by the three vertical rows of white dots between the tubes in the illustration. The brickwork is cut away from these doors at an angle of 45 degrees on each side, and individual blow-off holes are provided opposite the space between each two rows of tubes. By this arrangement a steam jet can be inserted between each pair of horizontal rows and also above the top one, and swung through a wide angle. By doing this from both sides the dust may be blown from the tubes quite effectively.

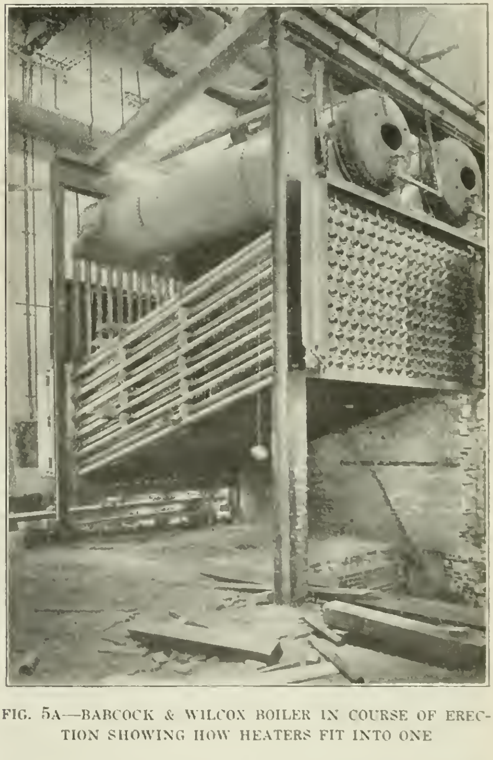


FIG. 5A—BABCOCK & WILCOX BOILER IN COURSE OF ERECTION SHOWING HOW HEATERS FIT INTO ONE

The headers are provided with holes in each side exactly like the water legs of the Heine boiler, the outside one being covered by a cap, held to place against the pressure of the steam with a bolt pulling against an inside dog. This puts the joint on the outside of the header, and these are all ground so that a metal-to-metal joint can be made.

These caps give access to the inside of the tubes for cleaning exactly as in the Heine boiler, and like it at the expense of two hand-hole joints to make for each tube, to which some operators object on account of the pains necessary to keep these joints in good order, although if they are made thoroughly tight before the boiler starts up they seldom give trouble in operation.

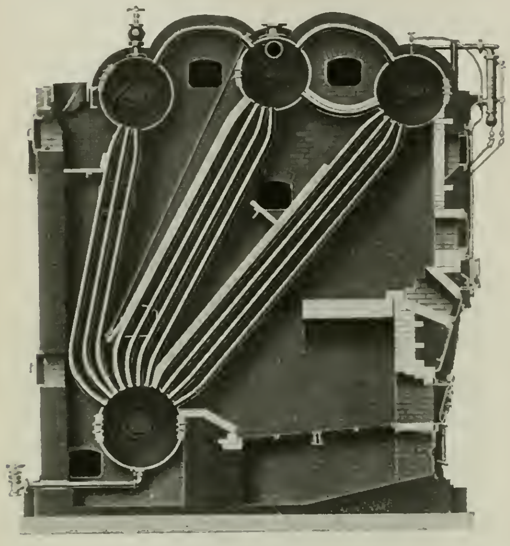


FIG. 6—STIRLING BOILER IN SETTING

### The Stirling Boiler

This boiler and its setting are both clearly shown in Fig. 6. This boiler is of an entirely different type from both the two preceding ones in two important particulars. First, there are no headers but three circular drums above and one below. From each of these three a set of tubes run to the lower one. Second, as the tubes all enter the drums radially they are necessarily curved at their ends to a greater or to less extent.

This construction eliminates the header altogether, but introduces the curved tube, and also cuts off access to the tube with a bar or cleaner of any type except a flexible one.

This for many years was the most serious obstacle to the continued successful operation of these boilers. They were furnished with scrapers mounted on chains with a weight on the end, this weight was dropped through each tube in turn and the scraper then pulled through after it. It will be seen that this was an exceedingly laborious operation, particularly as the drums are small, only 3 to 4 feet in diameter, and men could consequently only work lying down or crouched very low. The air in these drums is generally not of the best and the slightest leak of hot water from the steam connections above, or the blow-off below, makes them an almost intolerable place in which to do any work, especially the violent physical labor involved in hand-scraping.

These conditions have been very much changed by the introduction of power cleaners, which we will describe briefly at the end of this chapter.

The baffling in these boilers is inclined, but follows the line of the batteries of the tubes running to the different drums. The course of the gases is up, down, and then up through the stack connection to the draft opening just back of the rear drum. Three ordinary cleaning doors are provided above and one below, through which a steam jet can be introduced into the setting and the dust blown from the tubes, but owing to the steep angle at which the latter stand dust has not ordinarily the same tendency to settle upon them that it does on tubes that are approximately horizontal.

The bottom drum serves as a mud drum, and the sediment concentrated by the evaporation of the water gathers there, at least in part, and is blown off through the blow-off valve.

The feed takes place in the rear drum above which is entirely filled with water, and from there the feed water passes forward to the second and finally to the forward drum, there being a set of water tubes below the water line, and also steam tubes above it, connecting the front and middle drums, which serve as steam drums, particularly the middle one.

The setting of this boiler is regularly provided with a partial combustion chamber, and, therefore furnace gases may be burnt under it by introducing the burner immediately above the fire-door, but for best results with furnace gases the setting should be modified by throwing its lower part forward so that the combustion chamber would be longer.

As between the Stirling and the Babcock & Wilcox boiler some prefer the Babcock on account of its straight tubes and ease of cleaning, while others prefer the Stirling, claiming that it gives drier steam, and because it does not have a multiplicity of hand-hole plates to put on, take off, and keep tight.

### The Rust Boiler

This is the latest developed of any boiler in extensive modern use. It was invented to solve what had seemed for many years an insolvable problem, that of making a boiler containing nothing but straight tubes, and yet using only circular drums. This seemed impossible, because it is necessary for the tubes to enter the drum radially in all the older constructions, and this means that all the tubes except one row must be bent to reach this direction, as is clearly shown by the illustration of the Stirling boiler.

Mr. E. G. Rust, then chief engineer and later general superintendent of the Colorado Fuel & Iron Company, overcame this difficulty by making a forged steel tube sheet for the drum, which was circular in its principal section, but which had forged into it cup-like depressions whose axis was not radial to the drum, but in the line which the tubes were desired to have. This is shown by Fig. 7. These tube sheets are made of sufficiently heavy material so that even after the drawing necessary to form these pockets the material is amply strong.

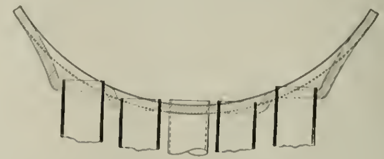


FIG. 7—RUST TUBE SHEET

The boiler in its setting is well shown by Fig. 8. It consists of four drums, two below and two vertically above, connected by five rows of straight vertical tubes. A bridge wall extends up from the foundation between the two elements of the boiler. The flame comes in on one side, passes vertically up, surrounding one nest of tubes, over the bridge wall and down, surrounding the other, thence to the stack. The bottom drums are connected by a single row of straight tubes, the top drums by an upwardly curved set of tubes for steam, and a downwardly curved set for water, the latter carrying baffle tiles to keep flame out of contact with the drums above the water line.

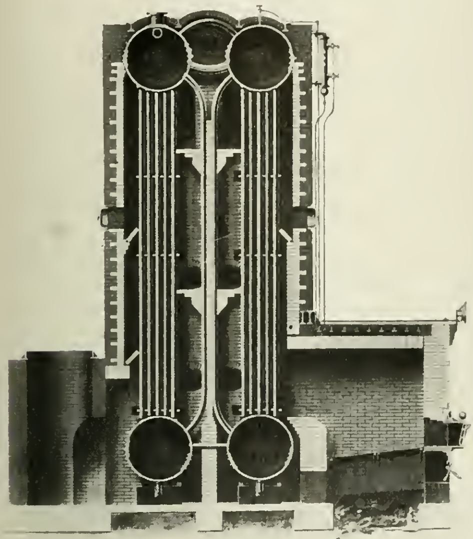


FIG. 8—RUST BOILER IN SETTING

One of the advantages claimed for this boiler is that the tubes being set vertically the dust has a minimum tendency to adhere to them, nevertheless three horizontal blow-off doors are provided which are of the same type as those described for the Babcock & Wilcox boiler, but set horizontally in this case so as to be at right angles to the line of the tubes. The setting of this boiler precludes the possibility of having the flame burn directly upward against the tubes, and owing to this construction a Dutch oven must be provided even with coal firing, which makes its adaptation to blast furnace gas very easy.

Fig. 9 shows the front of the battery of these boilers equipped with gas burners above the fire doors. The gas main may be seen in the upper right-hand corner of the illustration, and its connections to the individual pairs of burners. The valves controlling them, operated by wheel and hand-chain, are also shown.

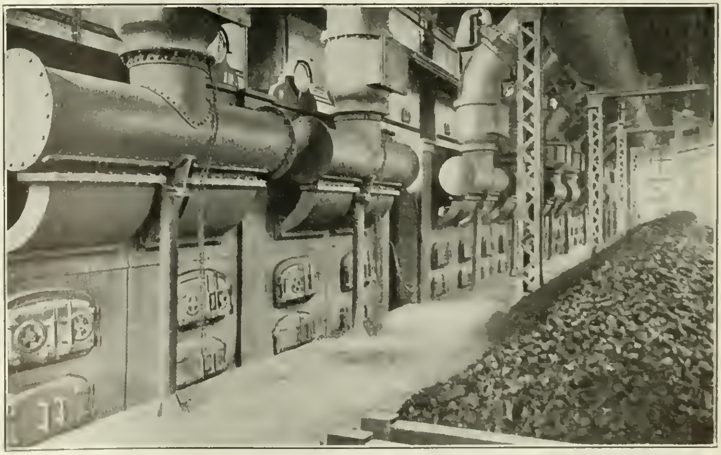


FIG. 9—SHOWING BURNERS FOR BLAST FURNACE GAS

It seems no more than fair to say that these boilers are generally preferred by blast-furnace managers who have used them above any other type.

### Gas Burners for Boilers

Blast-furnace gas is a relatively lean gas. When of the normal composition given above it requires about 60 per cent of its own volume of air for theoretically complete combustion, to which a small excess is generally added because while the losses from heavy excess of air are very great, those from unburnt combustible are still greater, and as it is impossible to maintain an absolute adjustment of air to gas it is better to err on the side of having a small excess of air rather than any considerable quantity of unburnt fuel.

In order to get the best results with the least excess of air an intimate mixture of gas and air must be made, and as the velocity of the gas through the boilers under the effect of draught is high the time for making this mixture is limited to a small fraction of a second. For this reason the entering currents of gas and air must not only be in intimate contact, but must present a maximum surface of contact for the area of opening required. This result is obtained either by the use of multiple ports for gas with air ports between, or by the use of a narrow port for gas with air on both sides. The latter is the type shown in Fig. 9.

The end of the curved flat burner projects into the front of the fire box with a clear space for air all around it. By the simple expedient of having a rectangular frame surrounding the burner and sliding on it, which can be pushed up close to the fire box front or drawn away as desired, the amount of air admitted may be varied at will, while the amount of gas may be controlled by the gas valve above. This provides independent regulation of air and gas, admitted to be a prime necessity for the most economical combustion of furnace gas.

In former times gas flues from the furnace to the boilers generally ran underground, and in these cases the burners were arranged to stand over an opening in the top of this flue. But such flues are unsatisfactory, both because of the difficulty of cleaning them out, which is still greater than that in the case of the chimney flues, and because being under the ground their tightness can never be insured, nor the amount of leakage from them determined, and leakage of furnace gas is not to be tolerated because only a few cubic feet in a large room are necessary to cause sickness and violent headaches, if not more serious consequences. Therefore, overhead mains of steel generally lined with fire brick are now commonly used, and the burners are suspended from them in some such way as that illustrated. This is a decided advantage, not only for the reasons given but because the burner is completely above and out of the way of the fire doors in case coal firing is necessary, which is by no means the case with burners coming up from below, which are not infrequently in the way at such times.

### Precautions as to Grates

When a Dutch oven or combustion chamber such as I have recommended is used the radiation from its roof or top surface is intense, while the grates are not protected by a current of air up through them as they are when coal is burned, since the air must be admitted with the gas for reasons explained above, and, therefore the ash-pit or draught doors must be kept closed.

For this reason the grates should be lightly covered with some substance such as coal, ashes or even a layer of brick laid loosely over them, to cut off the heat from above, otherwise the radiation from the arch is liable to melt them down or at least fuse shut the air openings. This would not be observed as long as the gas supply continued, but if in an emergency it suddenly became desirable to fire coal the grates being worthless none could be burned, and serious delay would result as well as the loss of the grates.

Very frequently the grates are protected by having a bed of coal spread on them which burns very slowly because no air comes up through it, the hot upper surface of which serves to light the gas instantly if the supply should fail momentarily and then start again. This is a matter of much importance, because if a mixture of gas and air fills the setting before ignition an explosion will result when ignition takes place, and the setting at least will be seriously damaged, even though the boilers are not thrown out of place and they or their steam connections ruptured. Accidents of this kind have frequently occurred, and too many precautions cannot be taken to avoid them.

### Boiler Cleaning

I have already described the earlier and cruder methods of cleaning water-tube boilers. It is not too much to say that these methods were so ineffective and the difficulty of keeping the tubes of these boilers in condition was so great that it seriously retarded the introduction of this type of boiler, because it must not be ignored that when a deposit of scale is formed inside of a tube it is reasonably secure from molestation even though the tube be taken out of the boiler bodily, so that tubes could not be cut out, cleaned off, welded up, and put back, practically as good as new, as is easily possible with the horizontal tubular boiler. This is so serious a consideration that the writer on one occasion needing additional boiler capacity installed a horizontal tubular boiler rather than contend with the difficulties of cleaning the water tube type.

In more recent years these conditions have been greatly improved for the water-tube boiler in two ways.

First, by the very general introduction at large plants which do not possess a natural supply of good boiler water, of purifying plants which neutralize any injurious acid which the feed water may contain (which in coal mining regions is sometimes a very large quantity), and then, by the addition of some suitable chemicals, precipitate out a large part of the scale forming material which the water contains, and throw that which is left into a form which makes sludge and can be blown out. Without such treatment this material settles on the tubes and other heating surfaces in a deposit almost as hard as iron, and almost as non-conducting as asbestos.

Second, by the introduction of power-driven boiler cleaners of various types. Generally the power is transmitted to the cleaner, either by water under pressure or by compressed air, the fluid under pressure in either case drives a motor of a size small enough to go inside the tube and pass through it freely. This motor carries at its forward end steel cutters of various forms, generally loosely pivoted to the shaft of the motor and thrown out to the wall of the tube by centrifugal force.

The motor is run at a very high speed and the rapid whirling of these cutters removes the scale which is carried out of the tube by the "exhaust" of the fluid which drives the motor.

Much ingenuity has been employed both in making and in selling devices of this kind, and some of them are extremely meritorious. The motors in general are of two types, turbine and sliding vane positive-pressure motors. It would be thought that this would be the ideal field for the turbine but I have obtained the best results with the sliding vane positive-pressure motor.

As between the two fluids, water and air, the advantages, in my judgment, are so strongly in favor of compressed air as to put it beyond comparison. This is for two or three reasons. First, the men working with the apparatus are at close quarters with it in a confined space, and no matter how carefully made and operated water-driven apparatus may be under such circumstances, it is impossible for the operator to avoid becoming wet and very dirty from the sludge produced by the grinding up of the scale. This makes the task an excessively disagreeable one for the operator, and reduces his speed in working at it materially. Secondly, the exhaust water from the motor cannot be prevented from reaching the brick work of the setting to a greater or less extent, and in the Babcock and Wilcox boiler it is almost impossible to prevent its running down into the underground flue with a bad effect upon both the draught and the flue.

With air none of these disadvantages exist. The air is perfectly clean, and its expansion even tends to cool to a small extent the air in the drums which the operator has to breathe, so actually ameliorating the conditions under which he has to work, while, of course, it has no effect whatever on the setting. Moreover, the amount of power needed may be transmitted through a much smaller hose with compressed air than with water, and, therefore the hose which connects the motor with the supply of power, and by which it is pushed through the tubes, is correspondingly smaller, lighter and easier for the operator to handle.

By the use of the best types of these cleaners boiler tubes can be kept clean at a fraction of the expense and with a fraction of the time lost from service that are required when hand-cleaning is used.

Moreover, it is very much to be doubted whether hand-cleaning ever cleans the tubes so thoroughly as do power cleaners no matter how conscientiously the former may be done.

I have seen the power cleaner applied to boilers supplied with the best natural feed water which had received the most thorough care, were thought to be absolutely clean, and were as far as could be seen, but at certain points the cleaner found and removed scale a quarter inch or more in thickness, which had been entirely invisible from the ends, although these were straight tubes.

Owing to the short length of these cleaners they may be used on curved tubes as well as straight ones and are equally effective therein.

This goes far to remove the disadvantage under which the Stirling and other curved-tube boilers formerly labored and to put them on a parity from an operating point of view with the straight-tube types. Of course, this does not remove their disadvantage in the matter of removing and replacing tubes.

The power boiler cleaner is like many other useful tools in that it must be used with care and discretion. In order to cut the scale the cutters must be good tool steel, almost as hard as glass and very sharp. In order to be effective they must run at a speed of many hundred revolutions per minute. It is obvious that if allowed to run in contact with the bare tube in one place they would soon cut it away enough to weaken it seriously if not to cut it through entirely, and the operator must be carefully instructed and advised to prevent this.

These two developments of the past decade and a half—the feed-water purifying plant which keeps out of the boilers much of the scale-forming material, and the power-drive tube cleaner which removes that which gets in—have reduced to a fraction of their former amounts the time, labor and expense of boiler maintenance, increased their average efficiency and decreased the percentage of spares necessary. They have thus gone far to solve the problems of boiler operation at blast furnaces.

## Notes on Chemistry and Metallurgy in Great Britain

(*By Our Special Correspondent*)

### Oil Shale in Skye

The shale deposits in the Island of Skye, which were described in a recent letter, have been further examined by boring, and although the shale thus obtained shows a considerably higher value than the samples taken when the announcement of the discovery was made last August, yet they are not rich enough to warrant the hope that the deposits can be worked profitably at present. The specimens taken in August were obtained from very badly weathered outcrops, and, of course, showed a very poor oil content. Lord Macdonald, the owner of the island, consequently had five borings made, and the samples from these show a yield of only some 19 gallons per ton—a result which can only be considered disappointing in view of the fact that in the Lothians a paying shale would produce quite 30 gallons per ton. It is possible, however, that some portions of the deposits in Skye may be of a better quality, and it is expected that further investigations will be made.

### Corrosion of Iron and Steel

Mr. F. Crosby-Jones recently read a paper before the Institute of Mining Engineers on "The Corrosion of Iron and Steel," and while he did not contribute anything new to the various theories of the cause and nature of corrosion, he made some valuable suggestions as to the practical methods of prevention of corrosion. He advocated that the same class of metal should be employed throughout all structures as far as possible, and that surfaces should be rendered smooth and without any depressions, pockets or cracks, which would be capable of retaining water. Free access of air to all members should be provided, and arrangements should be made for any necessary drainage of water. Special attention should be given to joints, rivet-heads, nuts and bolts to effect complete exclusion of wet and moisture, while a most careful inspection of all parts which were not easily visible was most essential. With regard to painting, inspection would be much facilitated by having each coat of a different shade, and a check could be more easily kept on the number of coats supplied. Perhaps the most important point was that the metal should be thoroughly cleansed and dried before any protective coating was put on, and even then it was necessary to employ a good and suitable material and to insure that the work was efficiently done.

### The Progress of the Electric Furnace

It has been generally supposed that British smelters and refiners have shown considerable reluctance to adopt the electric furnace, but statistics go to show that after all they have not lagged very much behind other countries. There are now 14 electric furnaces at work in England, 13 in France, 20 in Italy, 17 in the United States and 32 in Germany, besides a few in other countries, making a total for the world of something between 140 and 150. A remarkable fact is that in Germany 50 per cent of the furnaces are of the induction type and 50 per cent of the arc type. Out of the 20 Italian furnaces 19 are arc, as are 10 out of the total 13 French, and 13 out of the 14 English. The Heroult, the Girod, and the Stassano are the arc furnaces most numerously adopted, while the Kjellin and the Röchling-Rodenhäuser occur most frequently in the induction installations. The progress in Scandinavia is shown by the fact that Norway and Sweden employed only nine furnaces for the smelting of pig iron in 1912, and had more than doubled the number by the end of the following year, when 20 furnaces were in full operation.

### The Institution of Mining and Metallurgy

On the 13th of January the Institution of Mining and Metallurgy entered into possession of its recently acquired premises in Finsbury Circus, when the Lord Mayor performed the opening ceremony on the 22nd anniversary of the foundation of the institute. The membership has risen from 585 in 1899 to 2372 last year, and for some years the necessity of finding more extensive accommodation than was afforded by the old headquarters at Salisbury House has been increasingly apparent; but it is not always easy to find suitable premises in just the locality of the city in which the mining industry predominates. The building has been entirely renovated throughout, but the main architectural features have been interfered with as little as possible. The president, in calling on the Lord Mayor to open the building, said he wished to remind his hearers that practical metallurgy was very largely represented in London by extensive refining of gold and silver. The weight of gold melted at the Royal Mint and some other refineries amounted to 508 tons in 1812, and London was still in the proud position of being the only free market in the world for gold. It was their intention to present a petition to the King for a Royal Charter of incorporation by which the corporate existence of the members as metal miners and metallurgists would be recognized. The Lord

Mayor was then presented with a gold key, the wards of which were fashioned from the institution's initials.

### The Absorption of Gases by Celluloid

At the December meeting of the Chemical Society Mr. Victor Lefebure read a paper in which he stated that he had observed in celluloid an absorption of gases comparable with the absorption of gases by some kinds of charcoal. The effect was of the reversible order, and was not chemical because there was not any formation of a compound with a very low or moderately large dissociation pressure—it being assumed that such compounds would not form solid solutions with celluloid. The absorption occurred with all varieties of celluloid examined and reached a minimum in the case of a precipitate of celluloid constituents; but when this precipitate was reformed into a film the absorptive property recurred. The two chief constitutents of celluloid, nitro-cellulose and camphor, do not exhibit absorption. The effect was inversely as the temperature and directly as the pressure; and, in its general nature resembled a case of sorption. Diffusion experiments have established the fact of diffusion through films.

Professor Donnan, in the discussion, said that the rapidity of the initial absorption of carbon dioxide and the fact that the increase of the speed of absorption per unit weight of celluloid was greater than the increase of surface went to show that there was in the body of the celluloid—perhaps near the surface—a very fine-grained macro-porosity into which the gas could readily penetrate and be there absorbed.

Mr. W. P. Dreaper remarked that the porosity of structureless cellulose filaments could be widely varied by varying the strain to which they were subjected during the drying process of their manufacture.

### A Substitute for Petrol

Professor Vernon Boys, the well-known authority on gas-work chemistry and engineering, has devised and carried out a process for the commercial production of motor-spirit from heavy mineral oil waste, and states that the product is at least equal to ordinary petrol as fuel for motor engines. The heavy waste, heated to a fixed temperature, is subjected to the intimate action of steam, at 315 deg. C., which is then circulated through heated tubes containing a series of nickel rods. Hydrogen is liberated from the steam and combines with the finely divided particles of oil forming a substance closely resembling natural light petroleum spirit or "ligroin." The process is said to yield over 40 per cent of spirit from the crude waste: and the gaseous hydrocarbons which are also produced can be used for heating the tubes containing the nickel rods. A tarry residue remains and is available for further treatment or for other uses; and possibly—provided that a sufficient supply of waste oil were obtainable—the recovery of by-products might become worth attention.

### The Prevention of Scale in Boilers

A new device has been brought out under the name of the Vapor Scale Collector for which a high degree of efficiency is claimed in removing from the feed water those dissolved substances which under ordinary conditions contribute largely to the formation of scale.

The apparatus is simple, and consists of a series of partially perforated trays divided into compartments fixed in the steam space of the boiler and arranged so that the feed water passes in a cascade from the top tray to the bottom one with a wavy motion and at a rate which insures its attaining a temperature of 300 deg. F. before reaching the boiler water, when the feed is continuous and the boiler pressure not less than 85 lb. per square inch.

At this temperature carbon dioxide and dissolved air are completely expelled from the water, and a very large proportion of the scale-forming solids usually found in ordinary waters is deposited in the trays as mud and under them as stalactites. But, of course, most of the calcium sulphate, which goes to form hard scale, would not be thrown out of solution.

### Engineering Imports and Exports

The returns issued by the Board of Trade for the twelve months ended on December 31, 1913, show a very substantial improvement on the figures for 1912 in all classes of engineering materials and manufactures, especially with regard to exports. Imports of iron and steel, including manufactures, amounted to £15,230,694, an increase of £2,268,703, and exports totalled £54,328,292, an increase of £5,730,615. Other metals, including manufactures, were imported to the value of £32,102,246, a rise of £904,818, and were exported to the value of £13,288,350, an improvement of £1,003,879. Imports of electrical goods reached £1,587,318, and exports £5,404,671; the respective increases being £129,675 and £1,063,084. In machinery the imports were £7,282,046, a gain of £461,363; and exports went up to £37,027,582, which is a rise of £3,869,567.

The figures for the month of December alone are not so satisfactory. Imports of iron and steel increased by £208,139 on the value for December, 1912; but exports were £229,874 lower; imports of other metals fell £497,704, and exports decreased £126,979; imports of electrical goods rose £18,083, and exports were £26,345 higher; imports of machinery were only £3265 better, while exports improved by £214,122; new ships rose £1,171 in imports, but exports declined £394,484.

### Market Prices

*January*, 1914

| | £ s. d. |
|---|---|
| Aluminium ingots, in ton lots | 90. 0. 0 |
| Alum, lump, loose, ton | 5.10. 0 |
| Antimony, Star Regulus, ton | £28 to 30. 0. 0 |
| Borax, British refined crystal, ton | 17.10. 0 |
| Copper sulphate, ton | 22.10. 0 |
| Caustic soda, 70%, ton | 10. 5. 0 |
| Copper ore, 10 to 25%, unit | 11/ to 11. 6 |
| Ebonite rod, lb | 4. 6 |
| Hydrochloric acid, cwt | 5. 0 |
| India-rubber, Para, fine, lb | 3. 2½ |
| Mica, in original cases, medium | 3/6 to 6. 0 |
| Petroleum, Russian spot, gal | 9¼ |
| Quicksilver (Spanish) bottle | 7.10. 0 |
| Sal ammoniac, cwt | 2. 2. 0 |
| Sulphate of ammonia, ton | 12.10. 0 |
| Sulphur, recovered, ton | 5.10. 0 |
| Shellac, cwt | 4. 2. 0 |
| Platinum, oz., nominal | 9. 5. 0 |
| Tin ore, 70% ton | £103 to £105 |
| Zinc, Vielle Montagne, ton | 25. 0. 0 |

| *Higher* | £ s. d. | *Lower* | £ s. d. |
|---|---|---|---|
| Tin, ton | 10. 0. 0 | Borax, ton | 1. 0. 0 |
| Scotch pig | 7¼ | Sulphate of ammonia | 10. 0 |
| Cleveland | 9½ | Shellac, cwt | 6 |
| Lead | 2. 0. 0 | Zinc, ton | 12. 6 |
| Ebonite rod | 6 | | |

Copper opened £64 10s. 0d. and declined till the 9th, when it had reached £62 17s. 6d., recovering slightly on the 12th, it afterwards fell slowly, reaching £62 12s. 6d. on the 14th, and then recovered, rising until £65 7d. 6s. was touched on the 23d, and £66 on the 30th.

Tin opened £168 and fell away smartly to £166 10s. 0d. on the 5th, recovered on the 6th to £168 10s. 0d., and was £167 on the 8th and £167 5s. 0d. on the 14th, with recovery between. From the 15th, however, it became stronger, rising to £173 7s. 6d on the 21st and £177 on the 22d; the 23d saw a drop to £174 10s. 0d., and its subsequent recovery to £176 15s. 0d. on the 26th and £180 on the 30th.

# Symposium on the Undeveloped Elements

## Factors Involved in Opening Up the Field of Unused Elements—Papers on Cobalt, Boron, Ductile Tungsten, Selenium, Tellurium and Cadmium

The joint meeting of the New York sections of the American Electrochemical Society, the American Chemical Society, and the Society of Chemical Industry, held on the evening of Feb. 6 in the Chemists' Building in New York City, was exceedingly well attended in spite of the inclement weather. Mr. Lawrence Addicks, chairman of the New York section of the American Electrochemical Society, presided. The subject of the evening was a symposium of papers on "Undeveloped Elements."

Chairman Addicks in opening the meeting pointed out that "the number of known chemical elements is rapidly increasing and it is open to debate whether some of the brilliant work done in identifying new elements were not better applied to learn how to turn some of these already known to the use of mankind.

"In the earliest times we have the single conception of the unity of matter, which, strangely enough, we once in so often consider as still a possibility in explaining new discoveries. Then came the artificial classification of the early Indian and Greek philosophers, which were not rejected until shortly before the Christian era, at the beginning of which seven of the metallic elements were known—copper, silver, gold, tin, lead, iron, and mercury. The whole span of the middle ages and alchemy yielded but ten more elements, giving us a total of seventeen about 1750 at the beginning of Lavoisier's work. Sixty-seven elements were listed in Remsen's Chemistry of 1891. In the 1912 International Table there are eighty-two, and the end is not yet.

"Now I submit that a man's responsibility for an element should not end when he has proved his discovery by finding an atomic weight not already preempted and christened it with a name like a Pullman car, but that he should stay with it until he finds what it is good for. On the manufacturing side we have a similar situation. Many a concern will spend unlimited money to find just what substance will show certain desired properties, but, strangely, is unwilling to spend any money to develop uses for an apparently worthless by-product."

Mr. Addicks then introduced the first speaker, Dr. Charles Baskerville, who for years has made a special study of the less common elements and has conducted many researches along unused elements.

### Factors Involved in Opening Up the Field of Unused Elements

Dr. Charles Baskerville, professor of chemistry and director of the laboratory of the College of the City of New York, introduced his paper by giving two convenient tables "confessedly imperfect and based on capricious opinion." In the first table elements are given which are little used or are not used at all, while their compounds are used more or less. In Table II elements are given which are unused or little used both as elements and compounds.

TABLE I.—ELEMENTS LITTLE USED OR NOT USED, BUT WHOSE COMPOUNDS ARE USED MORE OR LESS

| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Unclas. |
|---|---|---|---|---|---|---|---|---|---|
| | Li | Mg | B | S | As | | F | Co | |
| | K | Ca | | Zr | | | Br | | |
| | | Ba | | Ce | | | I | | |
| | | Ra | | Th | | | | | |

TABLE II.—ELEMENTS OR COMPOUNDS UNUSED OR LITTLE USED

| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Unclas. |
|---|---|---|---|---|---|---|---|---|---|
| He | Rb | Be | Sc | Ge | Cb | Se | | Ru | Pr |
| Ne | Cs | Sr | Y | | Yb | Te | | Rb | Nd |
| A | | | La | | | | | Os | Sm |
| Kr | | | Ga | | | | | | Eu |
| Xe | | | In | | | | | | Gd |
| Nt | | | Er | | | | | | Dy |
| | | | Tl | | | | | | Tm |
| | | | | | | | | | Lu |
| | | | | | | | | | Tb |

About one-half of these have been discovered within the last thirty years. Those so recently made known are usually classified under the two groups of "rare gases" and "rare earths." The latter group is further conveniently subdivided under the heading of "rare earths" as follows:

TABLE III.—RARE EARTHS

| Ce Group | | Tb Group | | Yt Group | |
|---|---|---|---|---|---|
| Element | Atomic Weight | Element | Atomic Weight | Element | Atomic Weight |
| Sc | 44.1 | Eu | 152.0 | Dy | 162.5 |
| Yt | 89.0 | Gd | 157.3 | Ho | ? |
| La | 139.0 | Tb | 159.2 | Er | 167.4 |
| Ce | 140.25 | | | Th | 168.5 |
| Pr | 140.6 | | | Yb | 172 |
| Nd | 144.3 | | | Lu | 174. |
| Sm | 150.4 | | | | |

Dr. Baskerville called attention to the melting points and specific gravities of four of them.

Melting points: Ce = 623 deg. C.; La = 810 deg. C.; Nd = 840 deg. C.; Pr = 940 deg. C.; Al = 660 deg. C., and Ag = 960 deg. C., which gives a standard of comparison.

Specific gravities: La = 6.15, Pr = 6.48, Nd = 6.96, Ce = 7.04.

"Cerium has about the same density as Sn (7.3), but all of them readily oxidize on exposure to air. Cerium is between lead and tin in its physical appearance and harder than tin, while lanthanum acts much like metallic calcium, its oxide combining readily with water to form the hydroxide, being even air slacked (combining with carbon dioxide) as does lime." Dr. Baskerville exhibited small samples of these metals prepared in his laboratory, and in passing stated that the price of metallic cerium in Germany has fallen from 250 to 20 marks per kilo.

"The word 'rare' as applied above—as is the case with so many words of qualification—has changed its meaning in the light of very recent investigations, although the 'rare gases' are found in the atmosphere in the following proportions:

TABLE IV.—NOBLE GASES

| Name | Atomic Weight | One Part by Volume in Air |
|---|---|---|
| Helium | 4.0 | 2,450 volumes |
| Neon | 20 | 808 " |
| Argon | 39.9 | 105 " |
| Krypton | 81.8 | 746,000 " |
| Xenon | 128.0 | 3,846,000 " |

"Some of the elements mentioned above are by no means so uncommon now and may be had in commercial quantities." Table V contains these and some other elements, many of which have been known for a long time, not now used extensively, but inviting application.

TABLE V.—ELEMENTS NOW AVAILABLE, OR EASILY RENDERED AVAILABLE, IN COMMERCIAL QUANTITIES, BUT LITTLE USED

| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Unclas. |
|---|---|---|---|---|---|---|---|---|---|
| A | K | Ca | B | Si | As | Se | Br | CO | |
| | | Sr | Y | Zr | Cb | Te | I | Pd | |
| | | Ba | La | Ce | Ta | | | | |
| | | Cd | | Th | | | | | |

### FACTORS INVOLVED IN BRINGING THE FIELD UNDER CULTIVATION

"Let us see what are some of the factors involved in bringing the field under cultivation. I know how hard the work is. I have been a field hand for, as McIver once said, 'I've ploughed new ground with a blind mule.'

"In some cases we lay the lack of use of the elements at once to the scarcity of known occurrences. Haber has shown that osmium is the best catalyzer for making ammonia from its elements, but von Welsbach, who devised the osmium-filament lamp, has calculated that there are only a few hundred pounds of osmium available in the periphery of our globe. When, however, we remember that carbon is but 0.21 per cent, while silicon is 25.3 per cent of the crust of our earth for a depth of ten miles including the waters on the earth and its surrounding atmosphere, according to Clarke's calculations, we know that our present utilization of the elements commercially bears but little relation to their total quantity.

"With some striking exceptions, man has found more or less ample sources of the elements or their compounds when it has been shown that our civilization required them. I need but mention tungsten, thorium, vanadium, and radium in illustration. It is not the small percentage in which these elements occur, for palladium exists in nickeliferous pyrrhotites in quantities too small to be detected by even refined chemical analysis, but it accumulates in the slimes of nickel refineries and is thus obtained in some quantity. The price fixed by possession is the deterrent in the development of the use of palladium, a fact of no individual immorality, but contrary to the law of economics.

"Some ten years ago one large corporation possessing a store of palladium was approached by some technologists supported by good repute, with the idea of working out uses for that by-product. The owners said they were not interested in spending a thousand dollars on the investigation—they did not mind spending the money, but they would not be a party to lowering the price of the material in their possession, the inevitable result of extending its use. This principle is well illustrated in the history of metallic aluminium and thorium oxide whose market quotations have fallen to one-hundredth and two one-hundredths, respectively, what they were one generation ago.

"On account of its great resistance to atmospheric oxidation and moisture and to the effect of sulphuretted gases, palladium has been employed for the inner mechanism of chronometers and watches, for the construction of fine balance beams, for the divided scales of delicate apparatus, for surgical instruments. It has been used for coating silver goods, and for electroplating searchlight mirrors, for soldering platinum, and in dental preparations. Palladinized asbestos, palladium sponge and palladium black are most efficient catalytic substances for reducing purposes. This well-known fact may be flashed from the housetops without any fear of coagulating the clouds of litigation hovering over the oil-hardened situation in this country, as the parties referred to still own the palladium.

"Some of these 'unused' elements will be used if the prices are made more reasonable. A very important factor in reducing the market prices of these substances is an improvement in methods of extraction. This I may illustrate from the group of rare earths, not that I mean to lead you into that maze, but because it shows how modern tools have served the purpose and gives suggestions for needed extension with other elements among the 'meta-elements,' as Crookes termed them.

"Monazite sand is essentially a phosphate of the rare-earths containing valuable amounts of thorium, usually 4 to 6 per cent. The problem of obtaining thorium compounds from that source—315,000,000 Welsbach mantles was the world's output in 1913—depends upon (1) solution, usually by baking, with concentrated sulphuric acid and leaching. Very fine grinding of the sand was essential. (2) The rare earths and thorium are then thrown out as oxalates to remove the last trace of phosphoric acid. (3) The mixed oxalates were brought into solution with the destruction of the oxalic acid and the thorium precipitated or the oxalates were treated with ammonium oxalate whereby the non-hydrated thorium tetra-ammonium oxalate went into solution. This thorium salt was subsequently converted into nitrate. With all the price of thorium salts steadily declined until it seemed to reach a limit.

"Muthmann and Weiss conceived the plan of distilling of the phosphorus and converting the metallic elements present into carbides. The resultant mass is hard and is very expensive to grind in order subsequently to dissolve it. The writer later produced calcium carbide within the mixture of other carbides, using the unground monazite sand. This mass when thrown into water crumbles at once to a powder from which the suspended milk of lime is readily washed. The residual mass goes into solution in commercial hydrochloric acid from which the thorium may be precipitated at once in a form readily soluble in the nitric acid. The cerium may be thrown out of the solution from the thorium precipitate and tons of oxalic acid are now destroyed or locked up in the by-product of rare earths which are accumulating awaiting the development of uses.

"Muthmann and Weiss have applied the Hall process for the isolation of metallic cerium, whose use is now practically limited to pyrophoric alloys.

"Very recently it has been proven to be distinctly profitable according to separate patents of Soddy and Hahn, to separate meso-thorium compounds in the process of extracting and purifying the thoria. Mesothorium rivals radium in some of its applications in radio-surgery.

"The three instances cited above are given for another reason. The ideas were worked out by three college professors. Laborers must be provided for clearing the field, whether the toil be that of working out new processes to so reduce the cost of a material as to admit of its application to uses already known to exist or devise uses not known for by-products now quoted at fictitious prices, but which do not appear at such suppositious values in the annual financial statement.

"Undoubtedly the best way to work out problems of the utilization of 'undeveloped elements' is to attack them in such well-equipped and splendidly manned research laboratories as are maintained by the General Electric Company, the General Chemical Company, the Eastman Kodak Company, and others, but their upkeep involves large expenditures. Many colleges and university professors would welcome a subsidy work of this character, which should be scientific, dignified and help keep the wolf from the door. I commend for your amusing perusal 'The Confessions of a College Professor's Wife' in a recent number of the *Saturday Evening Post.*

"I do not mean that the college professor is prepared to or should go into the factory, but he can work at an idea, which should later be developed, if it has merit, on a commercial scale by the technical chemist or chemical engineer. Elaboration of this proposition, which is not novel with the speaker, is not necessary here. Suffice it to say that one so selected would bring to the problem a degree of ignorance that might be stimulating and a freedom from tradition which would admit of a display of imagination necessary to utilize material which is commercially abundant and inviting investigation.

"H. B. Baker has said somewhere, 'Nothing can be of more value to science than the exhaustive study of one particular action.' Weiss and Neumann have found that compressed zirconium is a conductor, whereas previous statements have been that it was non-conducting. There is need of reviewing many such statements that are handed down in the literature. Aluminium is sonorous, as according to so many textbooks. I have a sample of very pure aluminium, a part of which was used by Mallet in the determination of its atomic weight, and, as he assured me, it is not sonorous. If aluminium is sonorous it is not pure.

"Stewart in his charming book on 'Recent Advances in Physical and Inorganic Chemistry' in referring to 1887 and the following years of feverish activity in physico-chemical research, led by Arrhenius, Van't Hoff, and the elder Ostwald, says: 'To some extent, this wave appears to have spent its force. At the present day physical chemistry, except in the hands of a few exceptional researchers, has degenerated into a means of attacking the problems of pure chemistry instead of opening up new fields; and consequently there is a certain tendency to decry the subjects as a means to an end, and not a living branch of science. This is perhaps an exaggerated view; but it cannot be denied that physical chemists of the present day are not animated by the high hopes which seemed to have inspired Ostwald and others in the earlier days of the subject.' Bancroft acknowledges that there is some truth in this criticism, but asserts 'The difficulty is that most people are still struggling under the limitations imposed deliberately and consciously by Ostwald. Once these are broken through, nobody will have any cause to complain of the wave having spent its force.'

"Stewart further says: 'It is an extremely fortunate coincidence that as the first movement declined, a second and perhaps more powerful one had succeeded it. This second movement rose with even greater rapidity than pure physical chemistry, and yet at the present day we appear to have touched only the fringe of the subject of radioactivity; so that we may look forward to a long career of fruitful investigation still before us in this department of chemistry.'

"The problems of sub-atomic or electronic universe have presented themselves and at once we begin applying these new ideas to utilitarian purposes. The cryogenic laboratories have accumulated fractions from tons of liquid air. Collie found that neon luminesces under the influence of the Hertzian waves. A tube of neon serves as a detector of the nodes and loops, glowing brilliantly under the influence of the latter, as if it were excited by an induction coil. Tubes of neon prepared by Claude thus excited offer a most pleasing and perhaps later on an economical form of artificial light.

"Quantities of argon are now available from liquefied air. There are indications that, on account of its inertness, we may shortly see tungsten incandescent lamps, as Whitney puts it, with the 'vacuum jam-full of argon' instead of nitrogen. Troost and Ouvrard have stated that they have succeeded in causing argon to combine with magnesium vapor. Neither Rayleigh, Ramsay, nor Moissan were able to secure any evidence of the formation of compounds of argon, however. Many reactions unobserved on the laboratory scale are found to occur when dealing with large quantities of substances, through long periods of time. If this were not true we should have even greater difficulty in accounting for the occurrence of such inert gases as helium in malacome, cleveite and thorianite. It is thus barely possible that in time we shall find compounds of argon produced in the large-scale operations of burning the nitrogen of the air, as carried on so successfully in Norway at present. A use of compounds of argon may then be found.

The development of radioactivity has projected us into an undreamed realm of thought and new interests. The phenomena of radiology are closely allied to those of radioactivity. The use of Roentgen rays in medicine has been attendant with not a few difficulties. Among them the so-called 'hardness' and 'softness' of the rays. The former are the penetrating and affect tissues, sometimes favorably and sometimes unfavorably far below the surface. The 'soft' rays affect the epidermis. In the use of 'hard' X-ray tubes for deep treatment, it is necessary to screen the skin with various thicknesses of aluminium, or lead, etc. For treatment of skin affections only there have been no satisfactory means for screening out the penetrating rays, consequently the problem has been the production of 'soft' rays with a minimum of 'hard' rays.

"X-ray tube glass is usually a potash or soda lime silicate. Lindemann found that by substituting lithium for potassium the rays were 'softer.' He then substituted beryllium for calcium, and finally boron for silicon. Lithium-beryllium-boron glass shows over 30 per cent reduction in the empirical molecular weight. Windows of this glass let into X-ray tubes give the 'soft' rays desired. One of these tubes wherein three 'unused' elements are utilized was exhibited through the courtesy of Waite & Bartlett. It would be interesting to try a potassium-barium-zirconium glass.

"In connection with the above I show you samples of titan-quartz and zircon-quartz glass, for which original properties are claimed. Analyses of such quartz published in the *Chemiker Zeitung* show from 0.05 to 0.15 per cent of zirconium and 0 to 0.11 per cent of titanium oxide, so they are what they are not.

"Application of the newer electronic conceptions of valence especially when associated with residual affinity with the development of methods for changing valence according to our wishes will unquestionably cause many of these unused elements and many of those now most used to assume new properties. I call your attention to one qualitative illustration. Pure lead does not plate on iron. When molten lead is caused to flow to and fro as a conductor of a low-voltage, high-amperage alternating-current for variable periods of time, usually several hours, it then plates iron as may be seen from the sample so plated this week. The lead is pitted and the sample not perfect, but it points a way which may serve as a hint in seeking uses for such elements as cadmium, selenium, and tellurium.

"An indifferent and unsatisfying classification of the 'unused' elements has been attempted. Over one-third are little used. 'Rare' elements have been shown not to be so rare. Furthermore, rarity bears little direct relationship to utility. Desire to eat the cake and keep it at the same time are important factors in making use of some of the elements. Illustrations of the development of methods for reducing the cost of production have been cited. Means for stimulating work in utilizing elements now available have been suggested. These workers at least could correct much of the misinformation now transmitted by the normal channels from one generation to another. Directions in which real modern physical chemistry has made it possible to use some of these elements and opened up further possibilities have been mentioned. The limited time and assumed patience of our members have forced a degree of unavoidable superficiality.

"These joint meetings and one leading paper remind me of Jerome Travers and his 'Three Men in a Boat.' I have realized from the beginning that the task set me by your three presiding conspirators was no mean one and might perplex even Montmorency. If the weaving of the potash and pearlmutterings of the 'Unused Elements' into a dramatic curtain raiser has not carried interest and profit, lay it not to a sigh which has not been sensitive to lights and shadows but to a memory unable to recall the visions."

### Cobalt and Cobalt Alloys

The first paper dealing with a special undeveloped element, namely, cobalt, was presented by Dr. **Herbert T. Kalmus**, of the School of Mining, Queen's University, Kingston, Ontario, who has devoted several years of work to the study of cobalt and cobalt alloys. In view of the interest of the subject we herewith give Dr. **Kalmus'** paper in full.

The cobalt-oxide industry is a very old one. It probably started, on what might be considered a commercial scale, at Schneeberg, Germany, in 1520; about this time "blue cobalt," cobalt smalt, from Schneeberg, was being sold at Venice. The smalt contained about 6 per cent of cobalt. The smalt industry had a very interesting history in Saxony and Bohemia during the sixteenth to eighteenth centuries, during which time it grew very rapidly. F. Kapff, Finance Minister of Prussia, made a report of the industry in 1792, in which he estimated that thirty smalt works were at that time putting out 3000 tons of smalt per year.

At the present time these German and Austrian mines are important for bismuth and radio-active materials, the silver and cobalt having become quite insignificant. The historical development of this German silver-cobalt district is interesting because it probably forecasts the history of the present Ontario silver-cobalt camp, in that the production of cobalt continued over a long period after the camp had been depleted of its silver values.

During later years up to 1904-05, New Caledonia, New South Wales, Chili, Spain, Norway and Prussia supplied the world with cobalt. The output of New Caledonia at the time the Ontario deposits were discovered was probably 85-90 per cent of the world's supply. In 1904, Mr. A. Glasser, "Report in 1904, to the Minister of the Colonies, on the Mineral Wealth of New Caledonia," stated that New Caledonia has practically the monopoly for the production of cobalt for the whole world. The ores were not smelted or refined in New Caledonia, but were shipped to Europe to be treated.

The silver-cobalt mines of Ontario began to produce in 1904, and since that time they have wrested the monopoly in the production of cobalt from New Caledonia. The price offered for the CoO content of New Caledonia ores, running 8 per cent in CoO, had fallen from about 85 cents per pound in 1904 to approximately 20 cents per pound in 1908.

In the Ontario silver-cobalt district the more important ores in the veins are, native silver, smaltite ($CoAs_2$), niccolite ($NiAs$), chloanthite ($NiAs_2$), associated with which are usually found some dyscrasite ($Ag_3Sb$), argentite ($Ag_2S$), pyrargyrite ($Ag_3SbS_3$), Cobalt bloom ($Co_3As_2O_8 + 8\,H_2O$) and nickel bloom ($Ni_3As_2O_8 + 8\,H_2O$).

The metallurgical treatment of these ores is more or less secret, but a brief account of the Canadian practice may be found in the report of Mr. Arthur A. Cole, mining engineer, Temiscaming & Northern Railway Commission, Toronto, 1913.

Until the last year about one-half the ore from the Cobalt camp found its way to United States smelters. The ore is silicious and mixes well with United States basic ores. So far as the writer is aware the cobalt content of the ore shipped to the United States has never been recovered to any extent. The present United States practice leaves it in the form of residues containing Pb, Cu, As, Sb, S, Ni, Fe, Ag, and Au; that is, in rather bad shape to be treated for cobalt.

Up until the last year or so practically the only way which cobalt found its way into the industries was as cobalt oxide, $Co_3O_4$, for use as blue coloring substance. During the last few years the production of cobalt from the Ontario mines much exceeded the consumption of cobalt as cobalt oxide. The writer reported,[1] January, 1913, that the cobalt oxide industry consumed about one-third of the present output of the camp. During the last year the demand for cobalt oxide has considerably increased so that although the cobalt output of the Ontario mines is still very much in excess of the consumption of the metal cobalt, it is no longer true to the degree stated above. A considerable amount of statistical work would be required to make a satisfactory estimate of the present cobalt output of the Ontario mines, but you may take 1000 tons of cobalt metal per year as a rough working estimate, in order to orient yourselves as to the general magnitude.

In the year 1911 the Mines Branch, Canada Department of Mines, arranged with the School of Mining, Queen's University, Kingston, for researches to be undertaken with the view of extending the commercial usages and economic importance of the metal cobalt. To this end this laboratory has been operating continuously during 1912-13, under the direction of the writer.

Researches have been and are being undertaken under the following subdivisions:

I. Preparation of metallic cobalt by reduction of the oxide.

II. A study of the physical properties of the metal cobalt.

III. Electroplating of cobalt and its alloys.

IV. Cobalt alloys of extreme hardness.

V. Cobalt alloys with non-corrosive properties.

VI. Cobalt steels.

The first of these papers is in press, the second is ready for press and the rest will follow during the coming year. The experimental work on all of them has been so nearly completed that they probably can be finished during the present year.

It is impossible at present to give out the details of these investigations in advance of their publication by the Department of Mines, Ottawa, even were it possible to do so in a brief paper; however, the following general statements may be made as a result of the investigations and experiments:

(1) The preparation of black cobalt oxide, $Co_3O_4$, from Ontario silver-cobalt ores, has been worked out and is at present extensively practised at the Canadian smelters; therefore, this oxide was taken as the raw material for these investigations.

(2) Metallic cobalt, of a very high degree of purity, may be made from this oxide by reduction with carbon, with carbon monoxide gas, with hydrogen gas, or with aluminium; the former three at such tempera-

---

[1] Summary Report of the Mines Branch of the Canada Department of Mines for the year 1912, p. 94.

tures as to make it commercially attractive and economical.

(3) Metallic cobalt is not so closely identical with nickel in its properties as has been commonly considered.

(4) Cobalt is considerably harder than nickel, being about 125 on the Brindell scale of hardness, whereas nickel is about 65 on the same scale.

(5) Cobalt up to about 15 per cent, alloyed with steel containing small percentages of chromium and tungsten or molybdenum, yields alloys of extreme hardness, and of very superior cutting qualities when used as high-speed tool steels. Nickel substituted for cobalt in these alloys does not in any case give the same results

(6) The melting point of pure cobalt we find to be 1467 deg. C., to within 5 deg., whereas that of nickel is 1435 deg. C. Therefore, so far as its melting point is concerned cobalt is not very much more difficult than nickel to alloy.

(7) Pure cobalt has a higher tensile and compressive strength than any of the pure metals with which the writer is familiar. The effect of cobalt on the tensile and compressive strength of certain alloys and steels is being studied.

(8) Cobalt is magnetic at all temperatures up to about 1100 deg. C. We have found an alloy of cobalt and iron, approximately $Fe_2Co$, which has a magnetic permeability in strong magnetic fields about 10 per cent higher than the best Swedish soft iron. This has been independently discovered at this laboratory and by P. Weiss, Zurich, Switzerland.

(9) Cobalt alloys with chromium and the resulting cochrome may be swaged to form wires, which are in some respects superior to nichrome wires as heating elements; they are less readily oxidized at high temperatures, and have a higher melting point. The thermo-electric properties of cochrome are being studied.

(10) Small percentages of cobalt added to pure iron give alloys which are extremely non-corrosive and which will probably find extended use as sheet roofing materials. These are at present being tested on a commercial scale.

(11) Cobalt when electroplated on steel and brass gives a more adhesive plate with a more silvery appearance than nickel. It seems to be less readily corroded than nickel under ordinary atmospheric conditions and upon handling.

(12) Cobalt will probably find extended use in the plating industries for special purposes, even at a much higher price than nickel, in that it may be plated with extreme satisfaction from a more concentrated solution than nickel, and at a much higher current density. Cobalt can be deposited several times as rapidly as nickel.

The details of these observations, with numerical constants and complete data, are being and will be published during the coming year by the Mines Branch, Canada Department of Mines, Ottawa, and this brief preliminary note is given with the permission of the Director of Mines.

* * *

Dr. Chandler, called upon to open the discussion referred to some specimens from the Columbia University Museum, exhibited on the lecture table, and spoke of a cobalt anode which he had used many years ago and which had been made at Wharton's shop.

Dr. Baskerville called attention to some samples from the museum of the College of the City of New York, also exhibited on the lecture table.

In reply to a question Dr. Kalmus said as to a comparison of cobalt and nickel plating that a far purer anode of cobalt than of nicked could be used. This is of importance, as Mr. Addicks explained, because on account of the iron contained in commercial nickel anodes the nickel plating deposit will contain iron and therefore be liable to rusting.

In reply to a question of Dr. Richards, Dr. Kalmus said that alloys of cobalt and nickel had not yet been investigated.

In reply to another question as to further comparative data concerning nichrome and cochrome wire, Dr. Kalmus said that these could not yet be given, because the amount of cochrome wire made so far was very small.

Mr. Addicks called attention to a newly developed cobalt deposit, that of Katanga copper in the Belgian Congo, containing 6 per cent Co and 1 per cent Fe.

Mr. Cowles gave some interesting data on early work on copper-cobalt and zinc-cobalt alloys.

The chairman, Mr. Addicks, then passed over to the subject of boron with the following remarks: "Boron represents another class—unbalanced development. It is a peculiar element standing almost alone on the dividing line between the metals and non-metals. The supply is enormous and there is a large consumption of borax and boric acid. Other boron compounds have very limited application and elemental boron was a chemical curiosity until Dr. Weintraub, of the General Electric Company, discovered a glorified application of the borax assay bead, in that boron will deoxidize copper without leaving a dissolved residue, which depresses the conductivity." He then introduced Dr. E. Weintraub.

### Boron

Dr. E. Weintraub, of the General Electric Company, West Lynn, Mass., distinguished three periods in the recent development of boron. The first relates to the isolation of boron, the second to the technical applications of boron, and the third to their commercial utilization. We are now well ahead in the third period.

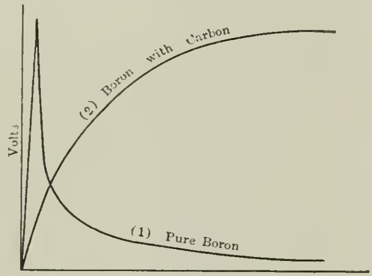
The main commercial uses of boron are based on its peculiar properties of high specific electric resistance and the negative temperature coefficient. The specific conductivity of boron of 0 deg. C. is about $6 \times 10^{-7}$ mhos per cm cube. This high-specific resistance of boron is accompanied by a negative temperature coefficient of resistance, which is also unprecedented among elements. The resistance of boron drops very markedly as the temperature is increased, and it does this with exceptional rapidity at ordinary room temperature. At this temperature the conductivity of boron doubles in value for every seventeen degrees centigrade.

The influence of addition of other elements dissolved in boron is no less interesting. This influence is of extraordinary magnitude so that even as small an amount as 0.1 per cent of carbon, for instance, will increase the conductivity of boron manifold. When 7 to 8 per cent of carbon are dissolved in boron the remarkable characteristics of boron disappear altogether and the material has a conductivity comparable to that of silicon or even carbon.

These peculiarities are best understood by considering the curve connecting the current and the voltage across a piece of boron. In such curves as shown in the diagram on page 186 the amperes are given as abscissas and the volts as ordinates. For a material with a negative temperature coefficient of resistance, such as boron, the curve is necessarily concave to the axis of abscissas.

In the adjoining diagram the curves are plotted not to scale, but simply to bring out the essential difference between pure boron and boron containing carbon. The curve (1) for pure boron shows a clearly developed maximum. That is, if the current passing through the piece of boron is gradually increased the voltage at the terminals of the piece of boron increases until it reaches a maximum; with further increases of current the voltage decreases. This property at once suggests the use of boron as a cut-out.

Dr. Weintraub expressed the belief that in such cut-outs boron will find a very large field of usefulness especially in connection with series lighting. Whenever the voltage rises beyond a certain value the boron cut-out which before had a very high resistance will break down and open a path for the current.



VOLT-AMPERE CURVES FOR BORON AND BORON-CARBON

If a little carbon is added to boron the nature of the volt-ampere curve changes and by adding more and more carbon the form of the curve (2) in the adjoining diagram may be obtained which reaches a maximum and then remains practically constant, becoming parallel to the ampere axis. Such boron-carbon resistors are practically applicable for voltage regulators. The principle is that if such a boron-carbon resistor is in shunt with a conductor to be regulated, and if the current fluctuates the boron-carbon conductor will absorb more or less current while the conductor in parallel maintains its amperes constant so that the voltage at the terminals remains constant. This property is made use of in car-lighting regulators.

Another type of boron-carbon resistors in an atmosphere of nitrogen (containing a little less carbon than the type just discussed) is employed for automobile lighting regulators to take care of the variations of speed. These regulators are placed in the field of the generator.

Dr. Weintraub finally discussed briefly the possible application of boron resistors as electric thermometers. On account of the great temperature coefficient they should be particularly applicable for such a purpose. The main difficulty has been to make reliable contacts with boron. This difficulty has been bad enough in connection with cut-outs and regulators but has there been completely overcome. On the other hand, this difficulty is much greater with thermometers as in this case the contacts must be absolutely constant. However, Dr. Weintraub concluded that he believed they were now at the end of the difficulties even in this case.

### Ductile Tungsten

Dr. R. W. Moore, of the General Electric Company, of Schenectady, N. Y., remarked in his paper on ductile tungsten that probably no other element has had such a rapid rise from comparative obscurity to great industrial importance as tungsten since the development of a process of rendering this hitherto extremely brittle metal ductile. Tungsten is by no means a rare element. The two chief minerals are scheelite (tungstate of calcium) and wolframite (tungstate of iron and manganese).

Scheelite is readily broken up with hydrochloric acid, forming calcium chloride, and leaving the tungstic acid mixed with the various insoluble portions of the ore (mostly silica). The tungstic acid may be dissolved in ammonia or caustic alkali and the solution then precipitated with acid to give the crude tungstic acid, $WO_3$.

Wolframite is most readily broken up by fusion with an alkali flux (caustic soda or carbonate) extracting the alkali tungstate with water and precipitating the tungstic acid as before. This crude oxide, roughly reduced with carbon, is the product used by the steel industry and is the metal that sells for approximately a dollar a pound.

But for the metal that is to be used for making ductile tungsten, this oxide contains too much impurity. The impurities vary with the ore, but the main ones are Fe, Mn, $SiO_2$, Ca, Mo, P, As, and Na salts. Two methods of purification are in general use:

First, solution in ammonia and crystallization of para ammonium tungstate. This is washed, dried and broken up by heat,

Second, solution in ammonia and precipitation of tungstic acid with hydrochloric acid.

A third method which is used where still greater purity is desired is a combination of the other two, i.e., crystallization and then the decomposition of the crystals with aqua regia.

The first method removes a large portion of all the impurities, but gives a heavy dense oxide from which it is more difficult to get a metal of satisfactory qualities.

The second method gives an oxide purer from some impurities than the crystallation method, but does not remove the P, and As at all completely; these, however, come out later in the process of working the metal. This oxide is light and readily reduced.

Two methods of reduction are being used, one with carbon and the other with hydrogen. By far the greater proportion of the metal used is hydrogen-reduced. Reduction by carbon is much less readily controlled, since under certain conditions the carbon may burn either to CO or $CO_2$; also some of the lower oxides of tungsten are volatile at fairly low temperatures. The finished metal must contain practically no carbon and practically no oxygen; also the density of the metal must not vary much from a certain standard, and it must not be crystalline. To realize all these conditions is somewhat difficult, but this method is in successful use.

The reduction with hydrogen is more readily controlled and is the process generally used. The oxide is reduced in electric resistance furnaces, with the temperature and rate of hydrogen-flow under careful control. The furnaces used are of two different types: First, porcelain tubes wound with platinum ribbon embedded in an insulating material either alumina or silica, and second, furnaces of the Winne and Dantsizen type, employing alundum tubes wound with tungsten or molybdenum wire, embedded in insulating material, contained in tight casings through which hydrogen is flowing to prevent oxidation of the winding. Each type of furnace has its advantages.

The oxide is loaded into the furnaces, either in boats, or directly into the tubes, purified and dried hydrogen passed through, and the temperature brought gradually up to about 1000° to 1100°. The rate of heating and the rate of hydrogen-flow largely determine the quality of the metal. This reduction process gives a completely reduced metal, without any crystalline structure; the density of the metal is under control and variable at will within the limits.

The tungsten thus produced is a dull-gray amorphous powder. The process of working this powder into a dough, ductile metal is radically different from any in use with other metals (except Mo).

Tungsten melts at about 3200°C. Even in spite of its extremely high melting-point, it is possible to form melted globules of tungsten of considerable size by means of a vacuum arc furnace. But tungsten that has been melted is extremely brittle and a globule of it when struck with a hammer flies into pieces like glass. It is impossible, at least, as yet to work pieces of tungsten which have been melted. Hence other methods of getting the tungsten into wire-form had to be worked out.

In the early days of the tungsten lamp, the tungsten powder was always mixed with some binder, either organic, like starch and the various gums, or metallic, such as some of the amalgams. The mixture was then squirted under pressure through dies, and the binder subsequently removed. Wire made by these methods was extremely brittle and fragile.

Since the process of making *drawn* tungsten wire was developed, practically all wire and other forms of ductile tungsten are made by the following process.

The dry tungsten powder, without binder of any form, is placed in a very heavy mold, care being taken that the powder is evenly distributed in the mold. The metal is then pressed into a bar by heavy pressure in a hydraulic press. This pressed rod has very little strength. It is carefully pushed from the surface of the mold into a slab of some material (usually molybdenum) and then placed in a furnace, usually of the Winne and Dantsizen type, heated to about 1300°. A current of hydrogen is passed through the tube to prevent oxidation. The bar is heated for about half an hour and then pushed out into a water-cooled extension of the furnace. This heating has sintered the metal so that the bar has sufficient strength to be readily handled without fear of breakage.

This bar is now clamped between two heavy water-cooled clamps, and a water-cooled cover or treating-bottle as it is called, is lowered over the whole. A current of dry hydrogen is passed through the bottle, and the bar then heated gradually up to a dazzling white heat—in fact nearly to its melting-point, by passing current through it. After a few minutes at this temperature the current is gradually turned off (to prevent air sucking back into the bottle and causing an explosion) and the bar allowed to cool. The tungsten is now thoroughly sintered and the bar is very strong—but as yet it has no ductility whatever.

From this point on, the treatment of the bars varies slightly, according to the use to which the metal is to be put. Sometimes the metal is rolled—sometimes swaged. The process in general is this: The bar is placed in an electric resistance furnace through which hydrogen is flowing, and heated to about 1500° C. (till it smokes in the air). It is then grasped with tongs and inserted rapidly into a swaging machine and then quickly withdrawn. It is reheated, and the other end passed into the machine. Care must be taken that the rod is passed rapidly into and out of the machine, so that it is not cooled too much.

The size of the dies is gradually decreased—several dies are used in bringing the rod from a square to a circular form. As the rod becomes smaller, the steps between the dies gradually become smaller and smaller, the temperature is gradually decreased, and when the rod is long enough it is fed through the machine mechanically by rolls, being drawn through a gas furnace or gas flame to heat it. When the diameter has been reduced to about 30 mils, the wire becomes ductile at ordinary temperature.

From this size, down to the smallest diameter the wire is drawn through diamond dies, first quite hot (600° to 650°) with a gradually decreasing temperature as the wire becomes smaller. The steps between the dies are gradually decreased from one mil at thirty mils to one-twentieth of a mil at fourteen mils and below. Wire as fine as one-half mil has been successfully drawn.

When not desired in the form of a wire, the treated bars are often rolled instead of swaged; sometimes both processes are combined. The metal is rolled hot in a manner similar to that used in swaging. From the rolled bars and sheets, various articles are made, such as contacts for electric apparatus of various kinds, X-ray targets, etc.

Tungsten is too hard to work on a lathe, or to be machined with tools. Hence other methods have to be used to get tungsten into any desired form. The metal sheets or bars are heated very hot, and then the desired pieces sheared, punched or forged out.

The properties of wrought or ductile tungsten are interesting. It is pliable, strong and tough. It is practically non-oxidized in damp air, and it resists acids to an unusual degree. It is unattacked by HF, only slightly attacked by HCl, $HNO_3$ or $H_2SO_4$ of any concentration hot or cold, or by aqua regia. Alkali solutions do not attack the metal, but fused alkalis dissolve it slowly. A mixture of $HNO_3$ and HF dissolve the metal rapidly. The specific gravity of tungsten is about 19.3. Its tensile strength is exceedingly high-samples of one-thousandth of an inch diameter have been obtained with a tensile strength of 600,000 to 650,000 lb. per sq. in. (several times that of steel).

The most important use for tungsten is, of course, as a filament for incandescent lamps. It is also being extensively used as a contact material where an electric circuit has to be made and broken repeatedly in the air, as in magnetos, etc., on automobiles, and in voltage regulators. Considerable use is being made of tungsten as a target in X-ray tubes, where it is being found exceedingly valuable. Tubes of tungsten are made and used as the heating unit in a furnace, in which a temperature of 2500°-2700° can be obtained in about five minutes, starting at room temperature. The furnace can be cooled and opened in about ten minutes, hence such a furnace is of the highest value in experimental work at high temperatures. The furnace can be filled with hydrogen or used as a vacuum furnace as desired.

A further use of tungsten is as a heater-winding for resistance furnaces such as the Winne and Dantsizen type and others. The temperature at which these furnaces can be run is limited at present only by the temperature which the tube or support on which it is wound will stand.

### Selenium, Tellurium, Cadmium

The chairman, Mr. Addicks, remarked that "selenium, tellurium and cadmium are three sad cases. The supply is fair and the consumption very small. Of course, they are used in medicine to a certain extent, but a doctor will use anything. The prescription of one of the fifteenth century physicians for the cure of fever began, after discussing the position of the stars: One heats in a brass pan 1½ oz. turpentine of cyprus and then introduce fifteen live spiders and mixes until the spiders have disappeared.

"Selenium has the property of imparting to the perspiration its characteristic odor, which is stated in the chemistries to resemble rotten radishes. It has been said that physicians find it an excellent ingredient for prescriptions where the patient is suffering from overwork and insists on going out to dances. . . ."

There was an interesting exhibit of several products of colored glass of the Corning Glass Works, of Corning, N. Y. In some interesting notes contributed by Mr. E. C. Sullivan it was stated that selenium produces a ruby glass much more satisfactory in transmission than any other ruby and they are using several thousand pounds yearly in the manufacture of such glass. Selenium, is recommended also for use as a decolorizer as it gives in small quantity a pink color which is complementary to the green color caused by iron.

With regard to cadmium sulphide they are using a few tons of this material annually to produce yellow color.

This company makes lantern globes and roundels for railway signal purposes, the red being obtained with selenium and the yellow with cadmium sulphide. Mr. Sullivan remarked that they were always interested in the less common elements since a decrease in price might make available for their use materials which are otherwise out of the question. Lithia and bismuth are possibilities along this line which suggest themselves at the moment.

In view of the late hour there was a comparatively brief discussion. Mr. J. B. F. Herreshoff spoke of the behaviour of selenium in the smelting and refining of copper and emphasized the influence of small quantities of foreign elements in copper on its electric conductivity.

After the close of the meeting the numerous exhibits on the lecture table were inspected with great interest by the audience. Besides the exhibits from the museums of the College of the City of New York and of Columbia University and of the Corning Glass Works there was also an interesting exhibit by Messrs. Eimer and Amend in charge of Mr. Childs. The whole evening was very enjoyable.

## An Apparatus for Making the Flash and Fire Tests of Lubricating Oils

BY H. L. SIEVER

By flash test we understand that temperature to which an oil must be heated to give off vapors, which when mixed with air produce an explosive mixture, while the fire test of an oil is the temperature at which it will give off vapors, which when ignited will burn continuously.

The latter temperature being obtained by continuing to heat the oil after the flash test is made.

Oils with a high flash point, such as lubricating oils, are as a rule made in an open cup or crucible, heated by a Terrill burner in an air or a sand bath.

The results obtained by making these tests in an open crucible are not always satisfactory.

There are several things to be considered when using a crucible, such as the quantity of oil, size of crucible, rate of heating, distance, and size of flame, draughts, etc., in fact unless these tests are made quite frequently one often forgets the exact conditions under which the previous tests were made. Porcelain crucibles are usually used for this purpose, but at high temperatures they often break, causing trouble, delay and expense. The accompanying illustration gives the dimensions for making a tester of machine steel which has proved to be very reliable and convenient in determining these temperatures.

It can be made of any cheap iron or steel at a small cost, and will last almost indefinitely.

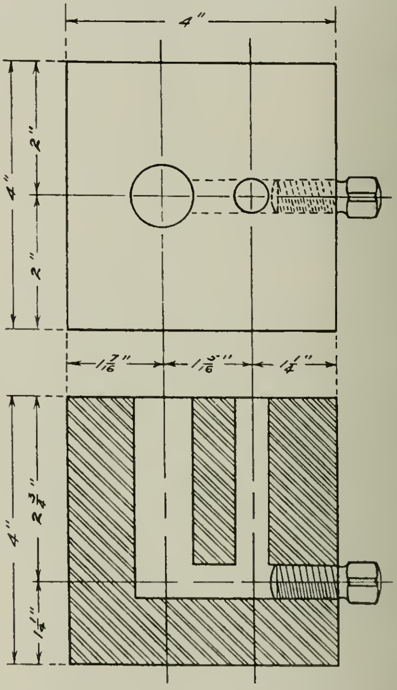
The advantages of this over an open crucible and sand bath are obvious. The most important being the volume of oil, which is the same for all tests, while the thermometer is entirely removed from the larger portion of oil where the test is to be made.

In practice this is placed on an ordinary iron support with a clamp for holding a thermometer.

Pour 35 c.c. of the oil to be tested in the large ⅞-inch hole and insert the thermometer in the small ½-inch hole, apply a fairly hot flame from a Terrill burner as near the center as possible.

The testing flame should be very small and applied at the edge or drawn across the top.

With this apparatus it is possible to accurately determine these temperatures to within one-half a degree.



SKETCH OF TEST ARRANGEMENT

By removing a set-screw with a pair of pliers the hot oil may be drawn off and arrangements made for a new test in a few minutes.

Laboratory, Morse Twist Drill & Machine Co.,
New Bedford, Mass.

**Preliminary statistics** of the value of metal production in the western states for 1913 have been given out by the Geological Survey: Alaska, $18,900,000, a decrease from 1912 of about $4,000,000; Arizona, $71,000,000 which is record output and an increase of 6 per cent; Colorado, $36,000,000 gold and zinc having decreased and silver, copper and lead increased; Idaho, $23,500,000, which is a record for that state and an increase of nearly 10 per cent; Montana, $59,000,000, a decrease of about half a million dollars, gold and copper having decreased while zinc made a record yield; Nevada, $36,374,000, a decrease of about 5 per cent, gold and lead having fallen off while silver, copper and zinc gained; New Mexico $11,600,000, an increase of $3,000,000, due mostly to copper; South Dakota, $7,200,000; Utah, $43,000,000, a slight increase. The production of coal, iron ore and petroleum broke all records, amounting respectively to 575,000,000 short tons, 58,000,000 long tons and 240,000,000 barrels.

# Mining Engineers' New York Convention

## Report of the Annual Meeting of the American Institute of Mining Engineers, Held in February in New York City

The annual meeting of the American Institute of Mining Engineers held in New York City from February 16 to 19 was a most enjoyable affair and was very well attended.

On Monday night there was a reception at the Institute's headquarters, opened by an address of welcome by President Charles F. Rand, and followed by a "mining-colored" smoker in which the humorous home talent of the Institute shone brilliantly.

The annual business meeting was held on Tuesday morning, when the results of the election of officers were announced. The number of ballots cast was 949.

Mr. Benjamin B. Thayer, president of the Anaconda Copper Mining Co., is the new president.

Messrs. H. C. Hoover and W. L. Saunders were elected vice-presidents and directors, and Messrs. R. W. Brock, D. C. Jackling, A. L. Ledoux, C. W. Merrill and Henry Smith, directors.

On Tuesday evening a meeting was held in the Museum of Natural History, at which the chairman of the New York section, Mr. L. B. Huntoon, presided. Mr. H. W. DuBois presented a beautifully illustrated lecture on "Placer Mining in British Columbia." The new model of the Copper Queen Mine, prepared with extreme accuracy and a gift of Dr. James Douglas to the Museum, was on exhibition. Dr. E. O. Hovey outlined the history and geology of the district, and Prof. James F. Kemp gave an appreciative sketch of the life and work of Dr. Douglas.

On Wednesday evening a subscription dinner at the Waldorf-Astoria was attended by some 200 members with their ladies. Mr. W. L. Saunders acted as toastmaster. Among the speeches, one by Senator Clark was particularly enjoyed. The banquet was preceded by a reception to the newly elected president, Mr. Thayer and the retiring president, Mr. Rand, and at the close of the dinner Mr. Rand introduced Mr. Thayer as the new president.

The professional sessions devoted to the reading and discussion of papers were well attended and extraordinarily successful. The scheme to give the different sections of the Institute a free hand in preparing the program and procuring papers proves very effective. During the last two days the program was so crowded that it was necessary to hold simultaneous sessions in two different rooms.

### Tuesday Morning Session

During the Tuesday morning session, which followed the annual business meeting, Mr. Spilsbury presided.

A paper by H. A. Guess on "Mining and Mining Methods in the Southeastern Missouri Disseminated Lead District," and a paper by James Johnston on "The Mill and Metallurgical Practice of the Nipissing Mining Co., Ltd., at Cobalt, Ontario," were presented in abstract by Mr. Robinson, in the absence of the authors. In view of the great metallurgical interest of the latter paper, we herewith give an abstract of the same:

### Nipissing Mill and Metallurgical Practice

At this mill a remarkably complex silver ore, averaging 54 oz. of silver per ton (run of mine ore) is treated to give a 95.66 per cent. extraction. Mr. Johnston points out that the main features of the processes are:

The cyanide amalgamation of the high-grade ore.

The cyanide treatment of the low-grade ore, after extremely fine grinding and close classification, in a caustic soda solution.

The use of a wet desulphurizing process to break up refractory silver minerals.

The substitution of aluminium dust for zinc dust as a precipitant.

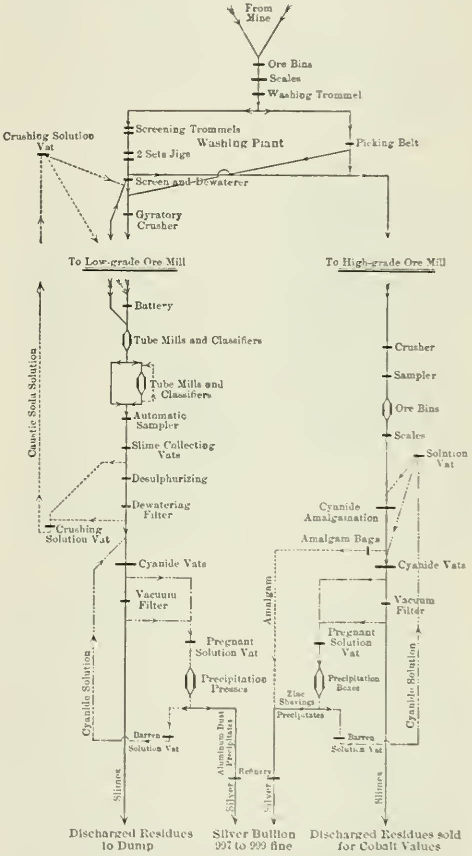


FIG. 1—FLOW SHEET OF NIPISSING MINING COMPANY'S MILL

The recovery and shipment of over 13,000,000 oz. of silver in bullion at 997 to 999 fine since this metallurgy was inaugurated, about 2.5 years ago.

After a review of the experimental work which preceded the design of the mill by Mr. Charles Butters and the author, the present mill practice is summed up as follows:

Crushing the ore to 3 in. in gyratory crushers before sending it to washing plant.

Hand picking and jigging of the high-grade ore in the washing plant, which is then sent to the high-grade ore mill.

Discards from washing plant, known as low-grade ore, crushed to 1.5-in. mesh and sent to battery.

Crushing in battery and tube mills in a caustic soda solution to all slimes.

Collecting slimes and desulphurizing in tube mill and vat.

Dewatering slimes and transferring to vats for cyanide treatment.

Filtering slimes and discharging to waste dump.

Cyanide solution from slime treatment vats and filters going to aluminium dust precipitation.

Aluminium dust precipitate taken to refinery, malted, and refined to silver bullion at 997 and 999 fine.

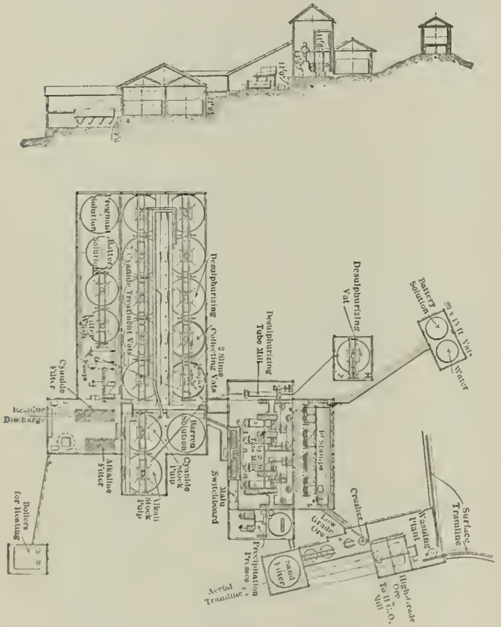


FIG. 2—PLAN AND SECTION OF THE LOW-GRADE ORE MILL OF THE NIPISSING MINING COMPANY

The flow sheet of the process is shown in Fig. 1, and the low-grade ore mill is shown in plan and section in Fig. 2.

Descriptions, with data on cost of erection, are given in the paper, of the foundations, the mill building, the washing plant, the battery, the tube mills, tonnage and values, launders, and the cyanide plant. The latter is placed in a building apart, but connected to the battery and tube mill building. It is arranged in two floors, the upper one containing all the slime collecting and the cyanide treatment vats and the lower floor containing all the solution vats, slime filters and pumps.

The desulphurizing process is an important novel feature of the process, so we give that portion of the paper which deals with it practically in full.

### DESULPHURIZING PROCESS

The problem of working out a successful all-cyanide treatment for Cobalt ores, in which there is such a varying amount of complex minerals, led to the discovery, during the period of experimental work, of what is now known as a wet desulphurizing process. Briefly explained, the preliminary desulphurizing treatment breaks up the refractory silver minerals when the slime pulp is brought into contact with aluminium in a caustic soda solution, the silver being left in a spongy metallic state readily amenable to cyanide treatment.

The desulphurizing is accomplished by passing the slime pulp through a revolving tube mill, in which there is a quantity of aluminium, and a further treatment is given in a vat lined with aluminium plates, in which the pulp is slowly agitated.

The practical effects of this preliminary treatment on the ores has resulted in the same and sometimes a better extraction being obtained in 48-hr. cyanide treatment than was otherwise obtained in 120-hr. cyanide treatment with no desulphurizing. In some of the ores which contained a greater proportion of the refractory minerals a better extraction of from 1 to 4 oz. per ton is obtained when desulphurized and cyanided, as compared with a cyanide treatment and no desulphurizing.

A tube mill, 4 ft. in diameter by 25 ft. long, lined with 2-in. thick Silex blocks, is used for the first stage of the desulphurizing treatment. This mill revolves at 10 revolutions per minute and carries a load of about 4000 lb. of aluminium ingots, cut up into cubes about 1.5 to 2 in. The slime pulp is fed through this mill at the rate of 14 tons of dry slimes per hour, diluted with 1.5 caustic soda solution to 1 dry slime. The pulp then gravitates into the 34-ft. diameter by 13-ft. deep alkali stock pulp vat, which is arranged with mechanical agitation and lined around the side with aluminium plates. The pulp is agitated in this vat about 24 to 36 hr., or until it is gradually drawn off in about 40-ton charges to the dewatering filter box. On account of keeping the mill cyanide solution in balance, it is necessary to eliminate as much as possible the crushing caustic soda solution from the slimes before they are transferred into the cyanide vats for treatment, and this is done in a Butters filter plant equipped with 60 leaves, which is capable of dewatering 270 tons of slimes per day, the cake when discharged carrying 26 per cent. alkali solution as moisture.

The slimes after dewatering flow into a 16 ft. by 5 ft. deep pulping vat, where they first come in contact with cyanide solution, being diluted with about 2 of cyanide solution to 1 of slime, a 4 in. diameter centrifugal pump being used for transferring the pulp into the cyanide treatment vats.

### CYANIDE DEPARTMENT

There are seven 34-ft. diameter by 13 ft. deep slime treatment vats, fitted with mechanical stirring arrangement. Each vat has a 6-in. diameter decanter, for draining off the clear settled cyanide solution they are also fitted with a 6-in. diameter air lift operated by 0.75-in. diameter pipe with air at 20 lb. pressure.

The slimes are treated in charges of about 130 tons dry slimes in a vat with a dilution of 2 of solution to 1 of dry slimes in a 0.25 per cent cyanide solution and 0.20 per cent alkali, agitation being maintained for 48 to 60 hr. Repeated testing in the mill has demonstrated that equally as good an extraction of the silver values is obtained with a 2 to 1 dilution as with a 3 to 1 dilution. The air lift is operated all the time the charge is being treated, so that there is a possible turning over of the charge about 16 times by the air lift.

After the agitation treatment, the charge is allowed to settle, so that the clear solution may be decanted to the pregnant solution vat. The pulp is then agitated and transferred by a 7-in. diameter centrifugal pump to the 34-ft. diameter by 13-ft. deep cyanide stock pulp vat, in which it is kept agitated until drawn off into the filter box.

A Butters filter plant equipped with 80 leaves handles 35 to 40-ton charges in about 3 hr. each, the slimes being discharged with 26 per cent of moisture. The alkali and the cyanide filters are arranged alongside of each other so that the same operator handles both boxes from the switchboard placed between them. The filter plants are arranged on the semi-gravity plan; a 10-in. diameter centrifugal pump with 12-in. diameter suction and delivery pipes and hydraulically operated valves is connected with the cyanide box for transferring the excess pulp and solution wash. The clear solution from the cyanide filter box is delivered to the pregnant solution vat and the residue slime is dropped into the empty box, discharging by gravity to the residue dump.

The alkali filter box is connected to an 8 by 10-in. duplex double-acting piston vacuum pump with a displacement of 340 ft. per minute at 160 revolutions per minute. The cyanide box has a 12-in. diameter by 10-in. stroke duplex double-acting piston vacuum pump with a displacement of 770 ft. per minute at 160 rev. per minute.

The pregnant solution vat is 34 ft. diameter by 8 ft. deep and the barren solution vat is 34 ft. diameter by 13 ft. deep.

### PRECIPITATION DEPARTMENT

The original plans of this section of the mill were laid out with the intention of using zinc dust for precipitation and an equipment was installed of one 20-frame and one 10-frame 52-in. Merrill precipitation presses with 3-in. frames, together with the other necessary machinery.

Before the mill was ready to start, the experimental work on the use of zinc dust as a precipitant had disclosed that the cyanide solutions after precipitation rapidly deteriorated and fouled, so as to lose their dissolving efficiency. After considering various other methods of precipitation, it was decided to use aluminium dust as the precipitant and modify the equipment accordingly.

The practical benefits gained by this change are:

No fouling of cyanide solutions, with a corresponding reduction in dissolving efficiency.

The working mill cyanide solutions are in a more active condition to dissolve silver than if they were freshly made up solutions which had not yet been used, showing in their favor an increased dissolving power of 0.35 oz. of silver per ton of ore.

A regeneration of 0.608 lb. of cyanide per ton of solution precipitated, equal to about 1.67 lb. of cyanide per ton of ore treated, or 408 lb. per day.

The recovery of silver precipitates averaging about 27,000 oz. per ton, or about 93 per cent silver.

The pregnant solution is pumped to the precipitation room by a 6 by 9-in. vertical triplex pump, running at 54 strokes per minute, where it is clarified in a sand filter before flowing to the special tank arrangement for mixing the aluminium dust in the cyanide solution. It is then pumped into the precipitation presses by another 6 by 9-in. vertical triplex pump. The 20-frame press takes about four days to fill up with precipitates when handling about 550 to 600 tons of solution per day with a head assay running about 8.25 oz. and a tail assay 0.10 oz. The aluminium dust consumption over a nine months' period averages about 0.556 lb. per ton of ore treated, or 1 lb. (avoir.) dust = 45.26 oz. (troy) silver precipitated, or 1 lb. (avoir.) dust ≐ 3.104 lb. (avoir.) silver precipitated. The precipitates are sent to the refinery, where they are melted and refined in a reverberatory furnace, as described in R. B. Watson's article, and eventually shipped as bullion at 997 to 999 fine.

A heating plant is provided which maintains an average temperature of about 60 deg. F. in the coldest weather, which is sometimes down to 40 deg. below.

The paper (which is published in full in the January issue of the *Bulletin* of the Institute) is concluded by figures of extraction, operating costs, and electric power.

In the discussion which followed, Mr. T. T. Read, emphasized how much valuable research work is now being carried out in this country. Mr. Spilsbury called attention to the high extraction obtained in comparison with the Mexican practice. Mr. Packard spoke on early pioneer work in Utah and Montana in the cyaniding of silver ores. Mr. Chauvenet attributed the recent big advances in cyaniding to two causes, namely, fine grading and the slime filter. Mr. Hore sketched the advances made at Cobalt in low-grade ore treatment.

### Tuesday Afternoon Session

During the afternoon session, at which Mr. Wm. Kelly presided, the chief subject of discussion was the use of electricity in mines. The program of the afternoon session was as follows:

Use of Electricity at the Penn and Republic Iron Mines, Michigan, by Wm. Kelly and F. H. Armstrong.

The Application of Electric Motors to Shovels, by H. W. Rogers.

Remarks on Electric Traction in Mines, by Charles Le Grand.

Safeguarding the Use of Electricity in Mines, by H. H. Clark.

The Safety of Underground Electrical Installations, by C. M. Means.

The Injection of Cement Grout into Water-Bearing Fissures, by Francis Donaldson.

Drilling Performances at the Kensico Dam, Catskill Aqueduct System, New York, by W. L. Saunders.

The Work of Crushing, by Arthur F. Taggart.

### Wednesday's Sessions on Iron and Steel

Papers on iron and steel were presented in the two sessions on Wednesday. Dr. A. Sauveur presided at the morning session, and Dr. J. W. Richards at the afternoon session.

The first paper, by **H. M. Howe** and **A. J. Levy**, on the plastic deformation of steel during overstrain, was presented by Professor Howe. The subject was discussed on the basis of a fine series of microphotographs, shown by lantern slides. The paper was discussed by Professor Carpenter, of London, and Messrs. Hibbard, Webster, Sweetser, Lindgren and Howe. There was an enjoyable exchange of international pleasantries between Professor Carpenter on one hand and Dr. Sauveur and Professor Howe on the other.

A paper by **Albert Sauveur** on some heating and cooling curves of Carpenter's electrolytic iron followed. Dr. Sauveur concluded that the existence of A2 in pure iron as an independent point is no longer a debatable question. Whether this point is or is not an allotropic point appears to depend upon our conception of allotropy. The paper was briefly discussed by Professors Carpenter and Howe.

Two papers presented during the morning session dealt with manganese steel. A paper by **B. Hopkinson** and **Sir Robert Hadfield** on a research with regard to the non-magnetic and magnetic conditions of manganese steel was presented in abstract by Dr. Richards and discussed by Messrs. Potter, Howe and Sauveur.

A paper by **W. S. Potter** on manganese steel with special reference to the relation of physical properties to microstructure and critical ranges was presented by Mr. Potter. He showed a very long series of lantern slides and was complimented by Dr. Sauveur on the vast amount of information contained in the paper.

### Oxygen in Cast Iron

The paper by Mr. **J. E. Johnson, Jr.,** on the influence on quality of cast iron exerted by oxygen, nitrogen and some other elements, proved the most sensational and most debated paper perhaps of the whole meeting. The paper is printed in full in the January issue of the *Bulletin* of the Institute. We give here only an abstract of the paper with such information as was given by Mr. Johnson at the meeting on more recent developments.

Mr. Johnson's argument is as follows: Ordinary chemical control does not determine completely the quality of iron. Certain irons of apparently the same chemical composition, as determined by ordinary analysis, have different qualities, structure, strength, etc. These qualities are preserved on remelting and reappear in castings of which these irons form an important ingredient. The explanation cannot be found in the rarer elements, such as nickel, cobalt, chromium, titanium, vanadium and the like. All this is proven by a great deal of experimental evidence.

As it seemed inconceivable that a quality which would survive remelting and superheating to a point well above the fusion point, as in foundry practice, should be a purely physical quality, the explanation was sought in the common gaseous elements, oxygen, nitrogen and hydrogen. Mr. Johnson claims to have found the explanation in the oxygen content.

Mr. Johnson discusses the content of oxygen in coke irons and in charcoal irons and gives the results of tests proving the following two facts:

First, strong, tough irons of high chilling qualities contain oxygen in appreciable quantities. Weaker irons of similar analysis contain less or no oxygen.

Second, poor and normal irons may be improved beyond recognition by introducing oxygen into them.

As to the conditions in which the oxygen exists nothing is known. "We have been unable to detect it with the microscope, and we can only assume that it is some oxide of very much lower degree than any with which we are familiar."

Its effects seem to be two-fold:

First, it makes the iron very much more sensitive to chilling influences. One of these good irons if cooled normally will be only slightly harder than a normal iron, and on account of its fine, close grain will machine beautifully, but if the surface be chilled even slightly it begins to whiten up, and with a chill of any strength will be solid white at the edge, where a normal iron of the same silicon would show little chill, or none at all.

Second, the other principal effect consists in the extremely fine subdivision of the graphite in the strong irons, contrasting conspicuously with the large, coarse aggregates of graphite in the weak irons.

This was clearly shown by Mr. Johnson at the meeting in a series of microphotographs. These were shown in pairs. The two irons of the same pair had the same chemical composition, with exception of the oxygen. The two structures shown side by side showed clearly the large, coarse, aggregates of graphite in the low-oxygen iron (weak iron) and the finely subdivided graphite in the high-oxygen iron (strong iron).

A further condition which exists in these high-oxygen irons is that the tendency to form plates of eutectic and to form a spot in the center of the pig is entirely suppressed, no matter what the silicon of the iron may be, even with quite high carbons.

The subject is further discussed by Mr. Johnson under the following headings: Comparison of high-oxygen cast iron and malleable cast iron; reason for low-oxygen content ordinarily; condition for high-oxygen content; coke-furnace conditions as regards oxygen, the effect of different types of heat balance on quality of iron high versus low carbon; the effect of other elements (nitrogen, cyanogen, phosphorus, chromium, manganese), and the reason for the poor quality of manganese and chrome chills.

Mr. Johnson's final conclusions are summed up as follows:

"1. Irons which contain oxygen to a considerable extent, in a form as yet unknown, are stronger and tougher and have better chilling qualities than irons containing less of this element, but of the same analysis in other respects.

"2. Irons may contain a sufficient quantity of carbon to make them rotten and worthless through the predominance of the eutectic structure when deficient in oxygen, and yet, when they contain a considerable quantity of oxygen, be entirely free from this structure and of excellent quality.

"3. Furnace conditions control whether the carbon shall be below or above the eutectic ratio and the presence of much or little oxygen, the two dominant factors in the fundamental quality of the iron; that iron, broadly, being the best which is made at the lowest temperature.

"4. Charcoal irons can be made at temperatures several hundred degrees lower than are practicable with coke and have a great possible advantage in that respect. This is largely wasted without good furnace work in the broadest sense.

"5. Phosphorus up to 0.50 per cent or more exercises a beneficial influence on the strength of the iron and the depth and character of the chill. Phosphorus also has a tendency to reduce total carbon.

"6. Aluminium and titanium tend to reduce the strength and chilling power of the iron by removing its oxygen, but titanium may have an influence independent of this on account of its removing nitrogen also.

"7. Chromium and manganese have an almost identical effect in raising the total carbon and throwing it into the combined condition. The latter increases the chill and the strength, but the combined carbon so produced is in the form of eutectic plates, which deprive the iron of much of the strength which it would have with the same combined carbon in the absence of these plates.

"8. Chill produced by these elements cannot be expected to have the same wearing qualities as that produced by elements which do not further the formation of flat plates of eutectic."

The paper elicited a long and lively discussion.

Dr. Moldenke said that while he agreed with much that is in Mr. Johnson's paper, yet he could not accept his main conclusion that oxygen is beneficial.

Professor Howe pointed out that according to Mr. Johnson, not the oxygen itself but the resulting reduction of the graphite from large flakes to smaller particles is the really beneficial element.

Mr. Stoughton defended Mr. Johnson against the attacks of Dr. Moldenke. It is simply claimed that the irons with more oxygen content have a better structure. The oxygen may have an influence in throwing the eutectic point to the right, though there is no direct evidence for this statement.

Professor Campbell suggested a way how the oxygen may affect the method of throwing out the graphite—which is so important for the final structure.

After Messrs. Hibbard, Stoughton and Sweetser had discussed the existence or non-existence of such a thing as good iron that makes bad steel, and Mr. John Howe had called attention to some new test results not yet given in Mr. Johnson's printed paper, but confirming his claims, Dr. Moldenke reiterated his conviction that oxygen in cast iron cannot be beneficial. This, he said, was not theory, but the result of his foundry practice of many years.

In his final reply Mr. Johnson referred to some experiments made recently by him with the object of converting ordinary coke iron into iron of a grade equal or superior to charcoal iron. These experiments have been exceedingly successful. He took an ordinary iron of about 1 per cent silicon and cast 1¼-in. round test bars from it. He then treated this iron so as to introduce oxygen into it, and from this same heat cast additional 1¼-in. round test bars; after treatment the iron contained about 1 per cent of silicon as before. The first set of bars broke very uniformly at from 2000 to 2500 pounds, about the normal for coke iron. The set of bars made after treatment also broke very uniformly, but at from 3800 to 4200 pounds. This iron had the chilling power and closeness of grain of the best grades of charcoal iron. Some 2-in. square test bars were also made from the treated metal and these broke from 19,000 to 24,000 pounds on 12-in. centers. considerably higher than the most rigid specifications for the best grades of charcoal iron. The cost of this treatment is low. It is estimated that the conversion cost will range from $2.00 to $5.00 per ton, according to the daily tonnage converted.

### Heat Treatment of Steel Castings

A paper by Messrs. **C. D. Young**, **O. D. A. Pease** and **C. H. Strand**, of Altoona, Pa., was presented by Mr. Pease.

In an effort to employ cast steel of a stronger structure than that found is the annealed steel castings, the possibilities of heat treatment which will increase the strength without materially decreasing the ductility may be resorted to.

The paper gives a brief outline of what has already been done by the Pennsylvania Railroad Co. at its shops and test laboratories at Altoona, Pa., and is of material interest, as it indicates what may be done with steel castings when properly treated, thereby permitting in railway service greater strength of cast steel parts without any increase in weight or space.

The obscurity formerly surrounding the heat treatment of steel has been for the most part removed by the development of our knowledge of the critical points of steel, pyrometers, furnace construction, and the testing of the finished product.

The operations of the heat treatment proper are taken up under the heads of (1) heating for quenching; (2) quenching; (3) drawing.

(1) *Heating for Quenching.*—Heating for quenching is best conducted slowly, especially in the case of castings of variable thickness. Cracks may occur either in heating or in cooling, due to different temperatures at different points of the casting. The castings should be thoroughly soaked at the maximum temperature (generally 1500 deg. to 1600 deg. F.), 1 hr. being sufficient for sections 1 ft. in thickness. The minimum temperature which will produce the desired hardening effect will, in all cases, be found to be the most satisfactory, as the grain coarsens when the critical range is exceeded to too great an extent. All temperatures should be governed by a checked pyrometer with the hot junction to the heated object, and with several couples in a large furnace to insure a uniform temperature.

(2) *The Quenching Operation.*—The casting should be transferred as quickly as possible from the furnace to the quenching bath, and in the case of large castings, such as locomotive frames, this is by no means a simple matter. The largest castings are best handled by means of cranes and rollers.

The quenching agent employed is generally water or oil, preferably the former, because of its cheapness and drastic cooling effect, more readily breaking up the coarse cast-steel grain. With intricate castings it is generally best to use oil. With water, it is possible to have a large tank and a large running stream, serving to maintain a uniform temperature. Castings should never be thrown in to rest on the bottom of the tank, but should be agitated to prevent the formation of a coating of vapor, retarding the quenching effect. It is also best, whenever possible, to quench the thicker portions first.

(3) *The Drawing Operation.*—Whenever possible, the drawing should be done in a bath of some kind such as lead, barium chloride, a barium chloride-salt mixture, or oil. In the case of large castings this is manifestly impossible, and great care should be exercised in obtaining a uniform temperature in the drawing furnace.

The use to which the casting is to be put determines the drawing temperature, railroad work, by reason of the shock and vibration of the road, requiring high ductility at the sacrifice of some strength.

A table is given showing the results of some tensile, chemical and micrographic tests of commercially annealed and experimentally heat-treated cast steel bolsters. The paper also contains some microphotographs showing the inefficiency of the manufacturer's annealing and the effectiveness of heat treatment. From a diagram giving the average results of a considerable number of tensile tests made from large castings it appears that the heat treatment increases the elastic limit about 50 per cent and the ultimate strength about 25 per cent, without any material change in elongation. The paper was discussed at some length by Messrs. Kone and John Howe.

In the afternoon session the following two papers were read by title, in the absence of the authors:

The American Steel Rail Situation, by R. W. Hunt: Manganese Steel Rails, by Sir Robert Hadfield. The latter paper was discussed by Messrs. W. S. Potter and J. W. Richards.

The paper on blast furnace operation with a turbo blower, by S. G. Valentine, was discussed by Messrs. J. W. Richards, L. Waldo, J. E. Johnson, Jr., and K. Nibecker, the latter two speakers questioning the accuracy of the instrument calibration on which the claimed results are based.

The three papers just mentioned may be found in full in the February issue of the *Bulletin* of the Institute.

Then followed three elaborate papers, of which a report must be reserved for the next issue on account of lack of space in the present number:

Gas Cleaning at the Duquesne Blast Furnace, by A. N. Diehl (the discussion bringing out much interesting information on recent developments at the Edgar Thomson Works).

Utilization of Blast-Furnace and Coke-Oven Gases for Power Purposes, by Heinrich J. Freyn (discussed by J. E. Johnson, Jr., R. Moldenke and R. Lyon).

Pig Steel from Ore in the Electric Furnace, by Robert M. Keeney (discussed by Dr. Richards).

The last paper of this session was presented by Mr. C. B. Murray, on the need of uniform methods of sampling Lake Superior iron ore, which was discussed by Messrs. Kelly and Sweetser.

### Wednesday's Sessions on Mining Law

During the morning session Dr. J. A. Holmes presided.

The paper on The Disposition of Natural Resources, by G. O. Smith, was presented by the author and discussed by Dr. Raymond.

A paper by C. H. Shamel, "Should the Apex Law be Now Repealed?" was read in abstract in absence of the author, and was strongly criticized by Dr. Raymond, who objected with especial vigor to the proposal to have questions of fact decided by the U. S. Geological Survey and not subject to review by the courts. The arguments of U. S. Senator Walsh, of Montana, were in a similar direction.

This discussion was continued in connection with the paper by C. W. Goodale on "The Apex Law in the Drumlummon Controversy."

The morning session was concluded by the presentation of four papers by G. O. Smith, F. F. Sharpless, A. Burch and F. L. Sizer.

During the afternoon session the paper by Horace V. Winchell, who presided in the afternoon, was first presented on Why the Mining Laws Should be Revised. E. B. Kirby's paper on Mining Law Revision—How to Obtain It, followed. Senator Walsh, of Montana, finally gave a review of the present status of mining legislation at Washington. This elicited a general discussion, and it was again and again emphasized that to make a success of it the new code of mining laws should be drafted by experienced mining men who are also familiar with the law—not by lawyers.

### Thursday's Sessions

During the morning simultaneous sessions were again held in different rooms. In one papers on mining geology were presented, while the other was devoted to a very interesting symposium on petroleum or gas. This was continued in the afternoon, while in another room papers on miscellaneous subjects were taken up. These were of a metallurgical character and will be reported in our next issue.

There was a general consensus of opinion as to the success and enjoyment of this meeting. The next general meeting of the Institute will be held in the autumn of 1914 in Salt Lake City, Utah.

---

**Welfare and safety work** among the employes of the Arkansas Valley plant of the A. S. & R. Co., at Leadville, was one of the features of the company's operations last year. A committee having the matter in charge meets weekly with heads of departments to consider the health and safety of employes, and to adopt measures to prevent illness and accident. This movement has proved satisfactory.

**Transvaal Gold Production.**—The number of companies reporting to the Transvaal Chamber of Mines in October, 1913, was 60. The total quantity of ore milled during that period was 2,127,085 tons. There were 9729 stamps in operation with an average duty of 8.62 tons per 24 hours. Tube mills in commission numbered 286. The yield for the month was 718,431 fine ounces gold.

## Recent Chemical and Metallurgical Patents

### Cement

**Testing Portland Cement.**—A convenient test of Portland cement which will effectually show the character of the cement as to permanency or durability when made into concrete is of great importance. Mr. Howard J. Force, chemist and engineer of tests of the Scranton laboratory of the Lackawanna Railroad, has devised an easy and reliable test, as follows: Briquets are made up of neat cement with a sufficient quantity of water to make a fairly plastic mass. These briquets are made in the usual brass molds having a cross-section of 1 sq. in., and are placed in a moist closet, where they are kept for 24 hours. At the expiration of this time a number of these briquets, usually three, are broken in a testing machine, and another like number of the same briquets are boiled under pressure for about 2 hours. The pressure is preferably about 20 atmospheres, or 285 lb. per square inch, which pressure is conveniently produced by placing the briquets in an autoclave or digester which contains water of about 70 deg. F., then closing the autoclave and then raising the temperature of the water by means of a gas flame or other suitable source of heat. It takes usually about an hour to reach a pressure of 285 lb., and this pressure is maintained for about an hour. Upon the expiration of this time the flame is extinguished and the pressure is blown off, which usually takes 20 minutes. The briquets are taken from the water, and if they have not been injured by the boiling they are placed in a moist closet for about half an hour. The briquets are weighed and the gain or loss in weight is noted and the briquets are broken in a testing machine.

It has been found that only cement which is sound in every way and suitable for producing a sound and lasting concrete will resist boiling under pressure successfully. Cements which will pass this test successfully are such as have been carefully manufactured by grinding the ingredients very finely, for instance, so that 85 per cent of the ground material will pass through a sieve of 200 mesh to the inch, then calcined or burned at a high temperature, for instance, 2700 deg. F., and then again ground to about the same fineness, or cements which are made of ingredients which have been thoroughly seasoned for several months after calcination. Inferior cements which are liable to produce unreliable concrete will crack or disintegrate when boiled under pressure or show a decided loss in tensile strength. Practice has shown that a pressure of 285 lb. to the square inch is very effective for producing the conditions which will bring to light the character or quality of the cement under treatment, but this pressure may be varied as circumstances may require. The pressure should, however, exceed 50 lb. to the square inch in order to produce the desired result within a reasonable period of time, and the higher the pressure is kept the quicker the desired result is reached.

One of the advantages of this process is that the briquets will be in condition for testing after a treatment of a few hours' duration. A satisfactory quality of cement will show a considerable increase of tensile strength after having been boiled under pressure, as compared with the same cement which has not been so treated, the increase being 25 per cent or more, and an unsatisfactory quality of cement will crumble or disintegrate under the treatment described. The tensile strength of the cement treated under pressure should not be less than 400 lb. per square inch. The gain in weight by cement during the boiling under pressure should not exceed 1 per cent. The same test is also desirable for ascertaining the character of the cement with reference to expansion. For that purpose expansion bars are made of the cement mixed with water in the usual way with a cross-section of about 1 sq. in. and a length of about 6 in. The bars are placed in a moist closet and at the expiration of 24 hours are carefully measured. They are then placed in the autoclave and boiled under pressure as described, and at the end of that treatment are again measured. Cements which are constant in volume should not show expansion of over one-half of 1 per cent when tested under the above-described conditions. The pressures mentioned herein are measured from the atmospheric pressure as the zero. (1,085,977, February 3, 1914.)

### Gold and Silver

**Slime Filter.**—A new modification of the drum type of filter for the continuous treatment of metallurgical slime has been patented by Mr. **Henry Alinder,** of Milwaukee, Wis., assignor to the Allis-Chalmers Mfg. Co. Fig 1 gives a central sectional view of the machine, while Fig. 2 shows an end view, partly in section, taken on the line III-III of Fig. 1. In brief, the filter consists of a revolving frame onto which are attached a number of wedge-shaped filter cells, arranged between the spokes of the drum. As the drum revolves in a tank of slime, the submerged cells are under vacuum which withdraws the solution and forms a slime cake on the filter surface. As the cell emerges it is put under reverse pressure, which dislodges the cake and throws it into another tank for a second treatment.

Referring to the figures, there are two drums, each in a separate tank 22 and 23, and revolving on hubs 30 and 31, fixed to the shaft 8. The filter cells 2 are constructed of porous material covered with canvas in the usual manner. Each has a pocket 5 connected by pipes 7 and 21, with sources of vacuum and pressure, so that the former can be applied to the submerged cells and the latter to those emerged. Each cell has a discharge opening 3, through which the dislodged cake is directed into the adjacent tank. Spray pipes 1 and 101 are placed conveniently to supply water for flushing the cake from the filter surface. (1,084,383, Jan. 13, 1914.)

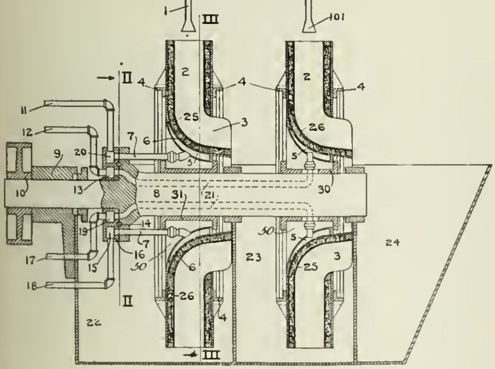


FIG. 1.—SLIME FILTER

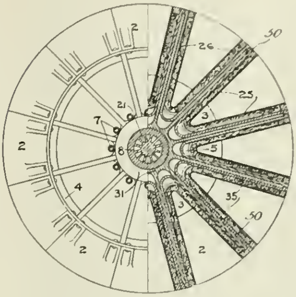


FIG. 2—SLIME FILTER

**Slime Agitator.**—In Fig. 3 is shown a vertical view of a form of mechanical agitator patented by Mr. **Frank E. Marcy,** of Salt Lake City, Utah, and assigned to the Allis-Chalmers Mfg. Co. It consists of a conical bottom tank with a central vertical tube, as in the ordinary form of Pachuca agitator. Instead of using air as the agitating medium, however, the inventor arranges pumping means in a T attached to the lower end of the central tube. Slime can enter the T pipe from either end, where it encounters screw pumps which force the pulp upward through the lift pipe. The screw pumps are placed at 10 and 11 in the figure, and are actuated by a motor 16, pulleys 17 and 18, and shaft 6. If solids should tend to clog in the conical portion of the tank they can be dislodged by introducing air or liquid under pressure through the pipe 15 at the bottom. (1,082,431, Dec. 23, 1913.)

### Copper and Zinc

**Basic-Lined Copper Refining Furnace.**—Improvements in the construction of reverberatory furnaces for copper refining are patented by Messrs. **Lawrence Addicks,** of Perth Amboy, and **Clarence L. Brower,** of Chrome, N. J. It has been customary heretofore to refine copper in a furnace having silicious walls and hearth with a cooling vault beneath. The silicious lining has furnished the necessary acid ingredient to slag off impurities in the copper, but the slag formed has been excessive, and there has been danger to the furnace structure from the consumption of the silica lining. The present inventors make use of magnesia

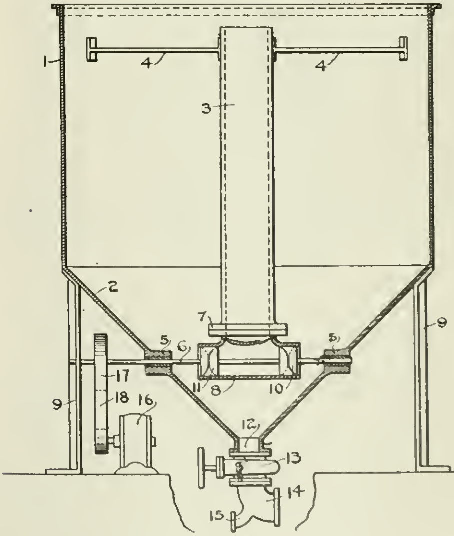


FIG. 3.—SLIME AGITATOR

brick in the hearth and chrome brick in the roof and walls, and find these materials superior to silica for the purpose. The furnace is constructed of a concrete and brick base, on which clay brick are laid in the form of an inverted arch. On this is laid the magnesite brick hearth, also in the form of an inverted arch, between skew-backs which receive the thrust and communicate it to the side supports. By a special construction the brick of the hearth are continued to the skew-back, beneath the side walls, and form a suitable base on which to build the walls. The magnesite bricks are laid in a mortar of magnesite dust and silicate of sodium solution.

Three classes of material ordinarily are dealt with in such furnaces: (1) Foul, such as junk, cement copper, etc.; (2) normal, such as blister copper from converters; and (3) pure, such as cathode copper. The basic-lined furnace is superior to the acid-lined furnace for the treatment of these materials. In the case of foul material the basic furnace permits separate treatment, with production of less slag and less danger to the furnace structure. In the case of ordinary blister copper the quantity of slag formed in the basic furnace is less than in one lined with silica. This is true also with cathode copper, where the slag formed amounts to less than one-half per cent with the basic furnace as compared with 3 per cent in the silica-lined furnace. Also, with the basic furnace this pure material requires only melting, whereas in the acid-lined furnace the same cycle of operations is gone through as in treating blister copper. (1,083,719, Jan. 6, 1914.)

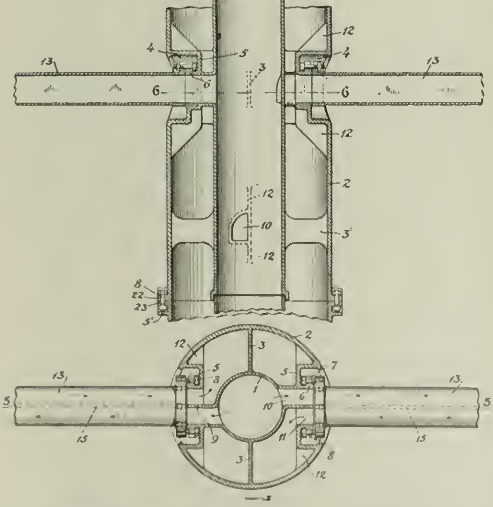


FIG. 4.—COOLING RABBLE ARMS IN ROASTING FURNACES

**Improved Form of Zinc Retort.**—The ordinary clay retorts used in spelter production are tubular in form and have appreciably flat surfaces on which slag dripping from a broken retort in an upper tier may lodge and ultimately puncture the wall and thus destroy an otherwise good retort in a lower tier. In order to obviate this destruction of retorts, Mr. **Harold W. Webster**, of Billericay, England, has patented a form having a sharp ridge along the top outside, resulting in increased thickness at this point and offering no surface on which dripping slag can lodge. The retort has a thickened and exteriorly flattened bottom which provides increased durability and a secure base for the support of the retort in the furnace. The rounded interior shape is preserved at both top and bottom of the retort.

### Fumes

**Mechanical Purification of Smelter Fumes.**—The recovery of mechanical impurities and the purification of the gases in smelter fumes is the subject of a patent granted to Charles S. Vadner, of Salt Lake City, Utah. The patent, in fact, refers to an acid smelter fume filter. The inventor in Fig. 5 shows its application to smelter fumes in general. The fumes coming from the smelter flue are led through the intake flue 1 into the recovery tower A, which has a sloping bottom 1', sloping away from the intake flue, while above the entrance of the intake flue there is a grate made of chemical bricks, 3, with suitable apertures entirely across the base of the recovery tower. Resting upon these grates are a number of spherical bodies, 4, of suitable size and character. The opening of the grate, 3, is smaller than the diameter of the bodies, 4. In the center of the recovery tower is a rotary stirrer, 5, with stirring arms, 6, provided with a pulley, 7, or other suitable means for the operation of the same outside of the recovery tower. These spherical bodies completely fill the recovery tower, and are prevented from falling into the outlet, 9, by the grate, 3, which is composed of chemical bricks, insoluble in acids, set at suitable intervals across the opening in the outlet. The fumes percolating upward through the irregular apertures between the suitable spherical bodies lose all their mechanical impurities, which become disposed in the interstices between the spherical bodies. The rotary stir, 5, is rotated, and by agitating the spherical bodies the mechanical impurities, consisting of gold, silver and other valuable metals, are permitted to fall down through the spaces in the brick grate to the sloping floor, 1, thence they may be drawn off through a manhole and returned to the smelter for the recovery of their valuable constituents. In this way all mechanical impurities are intended to be filtered from the fumes, preparatory to their passage onward through the outlet into other gas-treatment apparatus, where any combustible gases contained therein and other values are to be recovered. (1085712, February 3, 1914.)

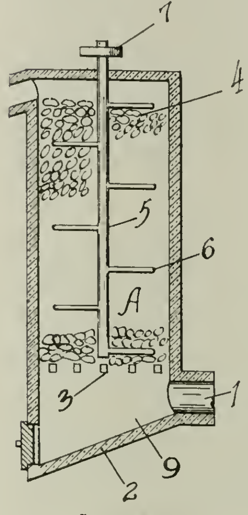


FIG. 5.—FUME FILTER

### Metallurgical Furnaces

**Cooling Rabble Arms.**—In roasting furnaces of the superimposed-hearth type it is advisable to cool the rabble arms in order to increase the life and efficiency of the furnace. Mr. **John B. F. Herreshoff**, of New York City, has recently patented an improved form of construction in which the central rotating member and the rabble arms are efficiently cooled by currents of air. As shown in Fig. 4 the central rotatable shaft to which the rabble arms are attached, consists of a central portion 1 and a concentric sleeve 2, held in concentric relation by strengthening ribs 3. At points of attachment of the rabble arms the walls of the sleeve 2 are recessed to form pockets 4. From the innermost walls of these pockets extend semi-circular flanges to which the rabble arms are attached by bolts. Each flange is provided with a vertical partition 9 which, together with the walls of the flange on one side of the partition, extends to the inner shaft 1 to form a passage 10. Each rabble arm is provided with a semicircular flange and with a central vertical partition from its inner end to a point near its outer end. Thus when the rabble arms are in place there is provided a continuous path for cool air from the inner portion of the shaft through one side of the rabble arm, back through the other side and into the inner portion of the shaft. The air current may be induced or forced in the usual manner. (1,085,419, Jan. 27, 1914.)

**Convertible Crucible-Retort.**—By the use of a particular type of crucible and cover in an ordinary tilting furnace, Mr. Willis W. Case, Jr., of Denver, Col., has made an invention which permits the use of the furnace for melting or retorting as desired. (1,085,540, Jan. 27, 1914.)

### Production of Thorium

**A method of producing metallic thorium** in a condition suitable for the manufacture of filaments for incandescent lamps has been patented by **Mr. William C. Arsem** and assigned to the General Electric Co. Metallic thorium hitherto produced has not been suitable for use as a filament, but according to the inventor's process it may be so produced. He converts thorium dioxide into thorium tetrachloride, and reduces this salt with sodium in a vacuum. The metal thus produced is washed and then compressed into a dense metallic state, from which hammered or drawn metal may be produced. (1,085,098, Jan. 27, 1914.)

## Synopsis of Chemical and Metallurgical Literature

### Iron and Steel

**Sintering Iron-Bearing Materials.**—The agglomeration or sintering of finely divided iron-bearing materials has become an important adjunct to the iron and steel industry, by rendering available for reduction in the blast furnace certain materials hitherto useless for that purpose. Thus, blast-furnace flue dust, finely divided concentrates and similar substances have been converted into a suitable blast-furnace feed. In the "Proceedings" of the Engineers' Society of Western Pennsylvania for December, 1913, Mr. B. G. Klugh presented the latest developments in this industry as exemplified in the Dwight & Lloyd process. This method of sintering was originally developed as a roasting process for sulphide ores in non-ferrous metallurgy, and is now widely used in that industry. Its extension to the iron field was a subsequent development, but is now recognized as an important means of agglomerating iron-bearing materials when mixed with a suitable proportion of fuel. There are now five Dwight & Lloyd plants in operation on iron materials, and thirty-eight in non-ferrous metallurgy. The iron plants treat pyrite cinder, flue dust, high-sulphur magnetites, magnetic concentrates, fine hematites, limonites and roll scale. For all except the flue dust it is necessary to add the requisite fuel.

The potent factor in operating this process is to maintain a permeable bed of mixture on the sintering hearth. This is affected by the quantity of water added, the method of adding the water and the method of delivering the mixture onto the hearth. The bed must be uniform in depth and consistency and the volume of gases passing through every square inch of bed should be progressively the same. Ignition is another important factor in efficient operation. Each mixture has an intensity of ignition for its most efficient sintering operation. Different fuels may be used. Of the five plants mentioned above two use fuel oil, two natural gas and one artificial gas. Fuel oil consumption is ¼ to ½ gallon per ton of product; natural gas, 60 cu. ft. per ton. Gasoline has been used and abandoned, but coal may be used advantageously under local conditions.

Early experience with the Dwight & Lloyd machines indicated a high loss of grate bars when sintering flue dust with a high fuel content, say 25 per cent. Since only about 8 per cent is necessary for sintering, the balance was burned out at the expense of the grates. Later this difficulty was overcome by covering the grates with a layer of lime or with coarse sinter which had been screened from the cake as it discharged from the machine.

While high-carbon flue dust can be sintered, it is considered advisable to use low-carbon material when possible. This can be secured either by concentrating the high-carbon dust or by diluting it with other fine material containing no fuel. The latter has been deemed the more profitable practice, although it is admitted that concentration yields a better material for sintering.

As examples of the value of sinter as a furnace feed, the author cites an Eastern furnace carrying a burden of 25 per cent sinter from flue dust and magnetic ore. With this charge the fuel has been about 10 per cent lower than before, when sinter was substituted for an old-range ore. There has been an absence of slips and scaffolds, and no action of scouring. A Southern furnace formerly carried a burden consisting of ¼ to ⅜ rotary kiln nodules, but never over ⅜ on account of scaffolding and scouring. Sinter has since been substituted and carried to the extent of one-half the burden, with a decrease in coke consumption, more regular driving and increased output.

In desulphurizing, the Dwight & Lloyd process has been successful in reducing sulphur in cinder from 2.0-6.5 per cent down to 0.10 per cent. Magnetite with 1.5 to 4 per cent sulphur has been reduced to 0.15 per cent.

The cost of operating a plant of two units is given in round numbers per ton as: labor, 18 cents; ignition, 6; repairs, 6; power, at 8.8 kw-hr. per ton, 16; total, 46 cents.

With cheap natural gas the cost for ignition would be only a fraction of a cent.

In the discussion it was brought out that material containing sulphur in combination with calcium and barium could be desulphurized to less than 0.1 per cent.

Weathered flue dust sinters better than fresh one. Different fuels can be used in the sinter mixture, as coke breeze, bituminous coal and anthracite screenings. In some experimental work charcoal, sawdust and lignite coal had been used successfully. Fuel containing sulphur does not affect the ultimate result in desulphurizing pyrite cinder. The quantity of air drawn through the bed is in excess of chemical requirements by from 50 to 80 per cent. The best pressure in 13 in. water gage.

It is preferable to use a constant-speed fan and regulate the permeability of the charge to conform to varying air requirements.

### Gold and Silver

**Flotation of Antimonial Silver Ore.**—In the November, 1913, "Quarterly" of the School of Mines, Columbia University, Mr. **Donald G. Campbell** describes a study of flotation as applied to a silicious ore containing pyrite, stibnite, and sulphides and antimonide of silver totaling about 5 or 6 per cent. The mineral was finely disseminated through the gangue, and necessitated fine grinding for its liberation. The ground pulp was subject to treatment according to the minerals' separation process of flotation, being mixed with water, oil and acid, and agitated to form a froth containing the mineral concentrate.

The oils tested were cylinder and machine mineral oils; sperm, fish and whale oils; corn, cottonseed and rapeseed oils; China-wood oil; resin oil; pine and pine-tar oils. In different experiments the effect of varying the acid, rate of agitation and temperature were tested. The summary of results shows:

1. Pine-tar oil was the most effective froth producer, and was most efficient when used in quantities approximating 0.1 per cent of the ore.
2. Without acid the froth is non-selective; that is, gangue is floated equally as well as mineral. The amount of strong sulphuric acid that seemed to produce the best results was approximately 0.4 per cent of the ore.
3. For good extraction the peripheral speed of the agitator blades had to be from 100 to 1200 ft. per minute.
4. Extraction increased with increase in temperature, and less oil and agitation were necessary. The amount of gangue carried into the froth was greatly lessened at higher temperatures.

### Copper and Nickel

**Roasting Copper-Nickel Matte.**—A study of some of the reactions taking place when copper-nickel matte is roasted is published by Messrs. **Edward F. Kern** and **M. H. Merris** in the Columbia School of Mines "Quarterly" for November, 1913. A summary of the results shows that in the analysis of copper-nickel materials copper may be separated from a sulphate solution by boiling with metallic aluminium in the presence of about 3 c.c. concentrated $H_2SO_4$ per 100 c.c. volume. When a mixture of nickel sulphide and copper oxide is heated small amounts of copper and nickel sulphates are formed when the temperature is between 525 deg. and 600 deg. C. Above 650 deg. C. these sulphates do not form, but cuprous sulphide and mixed subsulphide are formed; the higher the temperature the more rapid the formation of the cuprous sulphide. Nickel subsulphide is shown to be a stable compound, and does not react with copper oxide when a mixture is heated.

The roasting of nickel-copper matte proceeds slowly at temperatures below 600 deg. C. Above 730 deg. C. the matte becomes pasty and is not easily oxidized. The best conditions for rapid and complete roasting are, first roast for an hour at 450 deg. to 500 deg. C., with free access of air, in order to coat the matte particles with the thin film of oxide. The temperature can then be raised to between 675 deg. C. to 725 deg. C. Rabbling is necessary to prevent sintering of the mass.

### Tin

**Crushing Tin Ore with Nissen Stamps.**—Comparative tests of the value of Nissen and California stamps in crushing Cornish tin ore were recently made at the South Crofty tin mine, Cornwall. The results are reported in the *South African Mining Journal* for Nov. 8, 1913. Two Nissen stamps were run against 10 California stamps which are in the South Crofty mill. The following data show the comparative performance of the two types of stamp:

| | Two Nissen stamps | 10-stamp S. Crofty |
|---|---|---|
| Weight of stamps (lb.) | 2000 | 1050 |
| Number of drops per minute | 94 | — |
| Height in drop (in.) | 9 | — |
| Mesh of wire screen | 14 | 14 |
| Tons of ore crushed (2000 lb.) | 5.6 | 5.6 |
| Hours run | 6.50 | 3.25 |
| Tons per stamp per 24 hours | 10.33 | 3.75 |
| Units of power per hour | 7.85 | 20 |
| Cost of power per ton crushed (pence) | 5.46 | 6.96 |

*Grading Analysis.*

| | Nissen Stamps | | South Crofty Stamps | |
|---|---|---|---|---|
| | Dry Per cent. | Wet Per cent. | Dry Per cent. | Wet Per cent. |
| + 20 mesh | 3.6 | 3.5 | 2.7 | 2.2 |
| + 40 mesh | 22.4 | 22.7 | 17.4 | 16.9 |
| + 60 mesh | 9.9 | 10.9 | 8.5 | 8.0 |
| + 100 mesh | 20.8 | 18.8 | 20.5 | 19.2 |
| + 150 mesh | 10.6 | 7.0 | 8.0 | 7.1 |
| — 150 mesh | 32.7 | 37.1 | 42.9 | 46.6 |

The wet screen grading analysis, done to determine the amount of minus 200-mesh product produced, gave the following results:

| Discharge | Nissen stamps | Sth. Crofty mill |
|---|---|---|
| + 200 | 67% | 61% |
| — 200 | 33% | 39% |

The Nissen stamps have also been run on Carn Brea ore, and the results of the different trials are given below:

| Test No. | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Weight of stamps (lb.) | 2,000 | 2,000 | 2,000 | 2,000 |
| No. of drops per minute | 92 | 94 | 94 | 94 |
| Height of drop (in.) | 7 | 9 | 9 | 9 |
| Class of screen used | Wire | Wire | Wire | Cornish |
| Mesh of screen | 10 | 10 | 20 | 36 |
| Aperture, in inches | .654 | .064 | .028 | .028* |
| Tons ore crushed (2000 lb) | 12.20 | 17.75 | 3.36 | 5.26 |
| Hours run | 12.38 | 15.76 | 4.39 | 7.46 |
| Tons per stamp per 24 hours | 11.82 | 13.5 | 8.76 | 8.1 |
| Units of power per hour | 7.62 | 7.85 | 7.85 | 7.85 |
| Cost of power per ton crushed (pence) | 4.63 | 4.18 | 6.54 | 6.93 |

*Approximate.

*Grading Analysis*

| Test No. | 1 | 2 | 3 | 4 | |
|---|---|---|---|---|---|
| | | Dry % | Dry % | Dry % | Wet % |
| + 20 mesh | * | 13.1 | — | — | — |
| + 40 mesh | * | 23.1 | 14.0 | 5.4 | 5.1 |
| + 60 mesh | * | 9.8 | 10.9 | 13.3 | 12.9 |
| + 100 mesh | * | 19.9 | 24.2 | 28.1 | 27.3 |
| + 150 mesh | * | 8.9 | 12.5 | 10.5 | 9.4 |
| — 150 mesh | * | 25.0 | 38.4 | 42.7 | 45.3 |

*No samples taken.

The tests with Nissen stamps, we are informed, were all very much interrupted through lack of water, and it is considered that with regular running still better results would be possible. The result of the test in which a Cornish screen was used is regarded as particularly satisfactory, the screen analyses showing a much more granular pulp than usually obtained in Cornwall. This goes to confirm the opinion held by the inventor and manufacturers of the Nissen stamp that this mill would give not only an increased output at a lower cost for power, but also contribute to the securing of a higher tin recovery ratio, inasmuch as it would produce less slimes.

---

**Cement production in the United States in 1913** amounted to about 92,406,000 barrels, according to preliminary estimates of the Geological Survey. This is an increase of about 12 per cent over 1912. The average value per barrel is considered to be appreciably higher than in 1912. Increases of 10 to 25 cents per barrel have been reported from Rocky Mountain plants.

**Bureau of Mines publications** recently issued include **Technical Papers** 50, on metallurgical coke; 54, on errors in gas analysis due to assuming molecular volumes of all gases alike; 58, on the action of acid mine water on the insulation of electrical conductors; and **Bulletin** 58, on fuel briquetting investigations.

## Pressure Air-Cooled Roaster Furnace

The new Herreshoff pressure air-cooled roasting furnace has been brought to the attention of the metallurgical world within the last two years, although the furnace in its present development has been in use in acid works for a long time.

The furnace has been developed as the result of experiments with various sulphide ores for the purpose of making sulphurous acid gas. These experiments were conducted under the able direction of Dr. J. B. F. Herreshoff with the idea of designing a furnace which permits the use of higher temperatures than heretofore thought possible, without localizing a heat of such intensity as to endanger the slagging of the ore body, or destroying the working parts of the furnace.

To attain the above results, a long series of experiments were carried on, using such well-known cooling mediums as water, partially water and partially air, but these were found unsatisfactory in producing the ultimate results desired. The pressure air-cooled system was then adopted as it performed all the necessary functions, and at the same time simplified the construction and operation, to say nothing of permitting the utilization of waste heat.

The pressure air-cooling effect in the furnace is obtained by forcing air at 1 oz. to 3 oz. pressure by means of a fan, into the bottom part of the shaft, which conveys it to the arms, and thence in its heated state to the ouside air, or to the bottom hearth of the furnace for combustion, or both.

The shaft is made double, similar to any jacketed vessel, the outer shaft or tube being made of cast iron, the inner one of cast iron or steel. The rabble or rake arms are also made with this double effect, the inside tube of the arm connects with the inside tube of the shaft, while the outside tube of the arm connects with the outside tube of the shaft. The air supplied by the fan enters the main tube of the shaft, passes through the inner tube of the arm, thence through the outside arm and shaft tubes to the top of the furnace. Here it is either discharged to the open air, at temperature of about 400 deg. Fahr., or carried to the bottom or cooler parts of the furnace for combustion, either through the temperature control flues or the bustle pipe, or both.

The temperature control flues in combination with the bustle pipe and return pipes for waste heat perform two very valuable functions. The temperature control flues absorb the excess heat from the hottest zones of the furnace, and transmit it to the cooler ones; the return pipes take the waste heat from the top of the furnace and discharge it at the bottom or cooler zones of the furnace for combustion purposes.

It is plainly comprehensible, and has proven out by actual practice, that the embodiment of these two features will give a maximum capacity of sulphur per square foot of hearth area, without endangering the slagging of the ore body, due to localization of an intense heat in the central zones of the furnace.

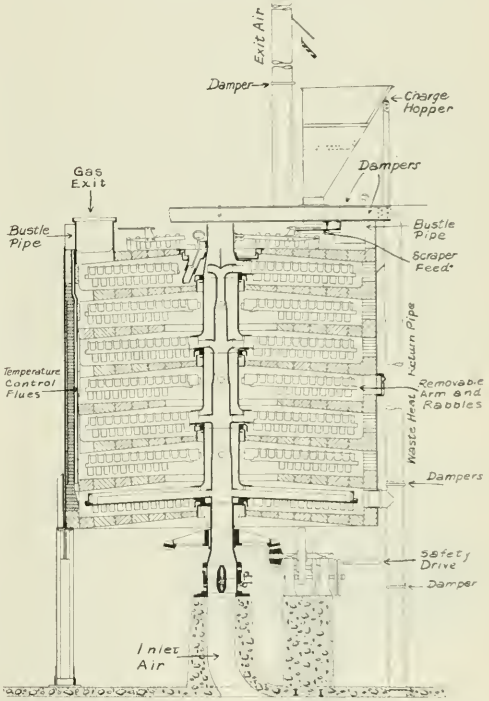
A detail feature which applies in our furnace is that the amount of air necessary to give sufficient cooling to the shaft and arms is approximately the amount necessary for combustion, making the temperature of the waste heat to be returned a maximum, thus giving the greatest efficiency for the utilization of the same. The damper control makes it possible to use just as much of the waste heat as desired, so that the control is flexible, making the furnace adaptable for burning various grades and quantities of ore within reasonable limits.

The removable rabble arms are made of standard steel pipe which makes them light for handling, and easily attainable at small cost, and their durability has proven superior to cast iron under actual working conditions.

The removal of the arms has proven by experiment a very simple and rapid operation, the same being performed on a hot furnace.

The removable rabble teeth are so designed, in regards to their pitch and progression, that they maintain a uniform thickness of ore bed over the entire hearth surface, and by means of the back and forward rabble effect the surface of the ore exposed for combustion is greatly increased.

These two features, the former permitting the ore to remain the greatest length of time in the furnace and the second exposing a larger surface for combustion, mean maximum capacity with thorough desulphurization.



HERRESHOFF AIR-COOLED ROASTER FURNACE. (TYPE SHOWN IS OF MEDIUM SIZE, SPECIALLY ADAPTABLE FOR A DEAD ROAST)

The openings for the passage of the gas between the hearths are designed so as to reduce the velocity of the gas to about 270 ft. to 300 ft. per minute, about one-third of the velocity found in most furnace designs, thus preventing the formation and entrainment of dust.

The ore feed is a very important feature. This is composed of a telescopic device attached to the hopper, which feeds the ore in a cone-shaped pile to a plate. From here it is scraped by knife edges, attached to the revolving drying hearth rabble arms, and when once set this simple indestructible feed delivers a constant quantity of ore to the hearth without further regulation. The ore then passes across the top of the drying hearth, in a thick or thin bed, as desired, according to the moisture in the same, and the variation of the speed of travel can be regulated by adjusting the relative position of the rabble teeth.

From the drying hearth the ore passes onto the furnace proper through a telescopic feed which also acts as a gas seal. This feed and dryer has proven very efficient in furnishing the furnace with a constant quantity of thoroughly dried ore which is essential for good operation.

A few words in regard to some of the details of construction may prove of interest. The shaft, flues, etc., are designed so that they are easily removable and wherever wrought iron or steel is used, it is either air-cooled or properly protected.

The bearings top and bottom insure perfect shaft alignment, and are so constructed that the horse-power for operation is reduced to a minimum.

The patent safety drive insures the rabble arms, teeth and shaft from breakage, should any foreign matter block the arms.

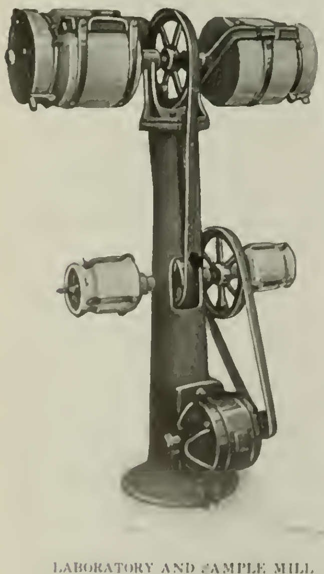
The furnaces are equipped with a sufficient number of specially designed doors, which are built for stability and convenience of operation. They are nicely machined and provided with sight holes, which are self-locking, making a gas-tight apparatus, not like the ordinary door which is not tight at the beginning, sulpates in a short time, and lets so much gas escape that the burner room, which should be a pleasant place to work, becomes a very disagreeable one.

In this article we have confined ourselves to points which apply on all furnaces, whether they are for a dead or metallurgical roast, and these principles also apply where extraneous fuel has to be used.

This furnace was developed by the General Chemical Co. through its Herreshoff Furnace Department.

## Laboratory and Sample Mill

The Abbe Engineering Company, of New York City, has added another mill to their large line of machines by putting on the market their combination laboratory and sample mill. This is really a combination of various sizes of their laboratory mills, fitted to a stand which makes a machine that is easily accessible from all sides, and being self-contained, may be placed in any part of a laboratory.



LABORATORY AND SAMPLE MILL

Where different diameter jars are used different speeds are obtained by means of belts and pulleys or silent chain gearing. A large number of different sized jars can be mounted on this type of machine, according to the requirements.

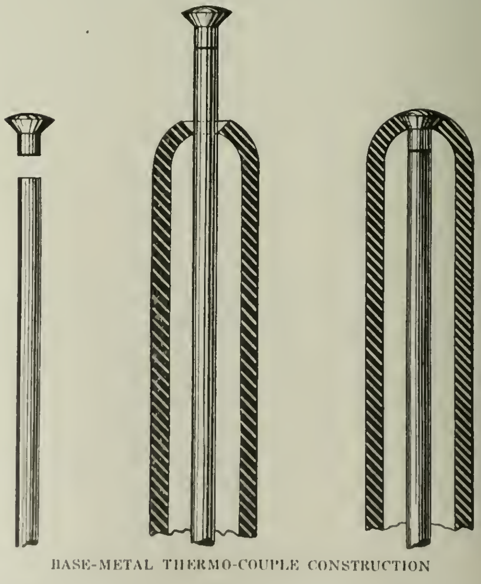
A novel feature is the motor fastened to the shaft of the column. This motor may be run from any commercial electric supply circuit and can be fed from any electric light socket. Another feature is that the mill being on its own arm pedestal a separate stand or table is not required. This also avoids the discomfort of stooping to change jars, when the mill is on the floor. When it is not desired to run the machine with a motor a pulley is furnished which may be belted to a line shaft.

## New Base-Metal Thermo-Couple

A new type of base-metal thermo-couple has just been put on the market which has several decidedly novel features of construction. The most frequent source of complaint of the ordinary base-metal couple emanates from its lethargy in indicating fluctuations. This has been due to the protection given the couple itself. Ordinarily this protection consists of an iron or steel tube through which the heat must travel and then heat the air within before it reaches the active portion of the couple, which in turn acts upon the instrument indicating the temperature.

In some cases this lag has amounted to 30 minutes, meaning that the actual temperature could not be read until 30 minutes had passed after exposing the couple to the heat of the frnace. This is about as bad a case as depending upon a watch which gets you to the depot 30 minutes after the train has left.

This great objection has been overcome in one type of couple by enclosing one of the elements in the second one, which is of tubular shape. The elements are welded together at the end and the couple is used in this form mostly without additional protection, making it thereby an exposed couple. But the products of combustion are liable to attack the couples and rapidly oxidize the exposed portions, and especially when immersed in molten metals the interior wire or rod, which is supposed to be the protected element of the couple, is gradually eaten into from the small portion of its exposed end.



BASE-METAL THERMO-COUPLE CONSTRUCTION

The new "simplex couple" brought out by the Stupakoff Laboratories of Pittsburgh combines the good qualities of the two types just described, and at the same time eliminates objectionable features. While the solution is exceedingly simple, it is unquestionably effective. It is accomplished by introducing as a new feature an internal weld, which forms the point of junction between the two elements of the thermocouple. One of the elements is a rod or a wire, and the second one, inclosing it, is of tubular form. A button consisting of the identical material as that of which the outer element is made is welded to the inner element, and after introducing this into the outer tube the head of the button is welded to the open end of the latter. Thus, the junction itself remaining at the very end, the completed entity represents a typical form of the exposed couple.

The accompanying illustrations, which are copies of drawings accompanying the application for United States patent, now pending, plainly show the various steps followed in the manufacture of this new device and need no additional explanation.

## A New Chemists' Slide Rule

By Harry R. Lee

The Keuffel & Esser Company, 127 Fulton street, New York City, have recently placed upon the market a new type of slide rule especially designed to meet the needs of chemists engaged in commercial analysis. The designer of this excellent rule and the author of the manual which is issued in connection with it, is Dr. R. Harmon Ashley, of the Chemical Department of the University of Maine. As the name implies, it may be used in the solution of any problem in stoichiometry within the list of elements and compounds printed on the rule.

Referring to the usual engineers' slide rule for nomenclature, the regular or front side of the chemists' rule shows the molecular symbols of 46 salts and 10 acids and bases on the A scale of the frame and a parallel list of these on the B scale of the slide. On the back appear the symbols of 42 elements and 37 oxides in place of the usual A scale on the frame, and a parallel list of these on the B 1 scale of the slide. The C and D scales on the front and the C 1 and D scales on the back are graduated numerically as is usual on the engineers' slide rule.

The principle of the application of the rule to the handling of chemical symbols and the corresponding atomic and molecular weights is clearly understood after passing the runner to a few of the elements on the A scale and reading under the runner on the D scale; in each case it will be seen that the atomic or molecular symbol with its graduation exactly corresponds in position with the proper atomic or molecular weight as numerically expressed on the D scale. The elements and compounds are, therefore, arranged in a list according to the ascending numerical values of their atomic and molecular weights and in no way does this arrangement depend upon alphabetical or chemical grouping. The symbols sought are located by approximate knowledge of their weights.

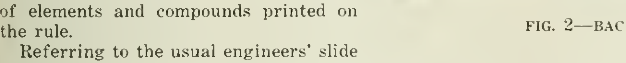


FIG. 1—FRONT OF CHEMISTS' SLIDE RULE

As in every application of the slide-rule principle, the distance of each symbol graduation from the left-hand index-line of the rule is proportional to the logarithm of the numerical value of the weight corresponding to the symbol. Salts and oxides are provided with short graduation lines, while acids, bases and elements have longer lines; this, with a little familiarity with the instrument, enables the operator to identify the line of the symbol for which he is looking, especially where approximately equal atomic or molecular weights of different substances necessarily crowd the graduation and printing.

The symbols listed comprise about all which will be needed by the chemist in ordinary commercial practice and is a remarkably good selection for the purpose. Those who need many symbols not given on the rule will for the most part be chemists working in the rarer elements and compounds, the nature of whose work will call for closer methods of calculation than a slide rule could possible afford.

In those cases where a molecular weight has not been inscribed on the rule, it is often possible to read off the weights of two, rarely more, compounds, the sum of which will give the molecular weight desired. Setting this sum on the proper numeral, the rest of the calculation will proceed as usual.

The sacrifice of the A and B scales on the front and of the A and B 1 scales on the back side of this rule to make space for the chemical symbols is the only way to effect the purpose of the designer. Those who will miss these features will recollect, however, that stoichiometrical calculations do not involve squares and cubes, or the corresponding roots and will turn to an engineers' rule for this class of calculation.

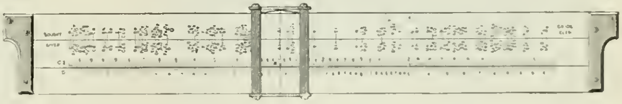


FIG. 2—BACK OF CHEMISTS' SLIDE RULE

The rule will assist in the solution of any stoichiometrical calculation, but is more particularly adapted to save time in handling the simpler ones, where most of the terms of the written expression are found to be molecular or atomic weights. In the extreme case of gas volume evolved from a reacting solid substance, the expression will involve the molecular weight of the latter, the gas factor 22.4, two temperature factors and two pressure factors, the result being the volume of gas at a prescribed temperature and pressure from a given weight of reacting solid. In this case 5 of the 6 factors being numerical and known, an ordinary slide rule would do nearly as well, with reference to convenience or time consumed, the rule furnishing only one chemical weight.

A feature of the rule which will appeal to some, who do not make a point of remembering the atomic and moleculer weights of a large list of elements and compounds, will be found in the fact that the numerical value of any of the 135 symbols listed may be read off on the scales D by the use of the runner, accurate to the first decimal place at least, depending on the region of the scale where the value may be found. For ordinary purposes the exact knowledge of the second decimal figure is unessential, and this will change yearly for many elements as new determinations are published. No changes of sufficient magnitude will occur, however, to place the rule out of date and it is built to last a lifetime of good care.

The manual is a pamphlet of 25 pages, written in a singularly clear and simple style, intelligible to those who have no acquaintance with the properties of logarithms and brief and clear enough to meet the needs of the technical man who wishes to know in the least time what he can do with the rule. The manual ends with a neat dissertation on the maximum error necessary in reading on three regions of the scale, which is unusual and gratifying to note. It is emphasized that the results from the rule are of as high order of accuracy as the chemical work which precedes its use, usually is expected to be. The reciprocal method of calculating any percentage is unique and very neat.

Holcomb Rock, Va.

## A Self-Cleaning Screen for Sewage and Trade Wastes

In order to dispose of sewage and trade wastes in a sanitary manner, unusual efforts have been exerted to meet these requirements by a successful separation of the solids contained in the sewage and the clarification of the effluent to such a condition that it can be discharged to streams without polluting them.

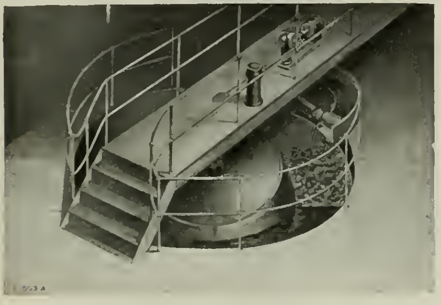


FIG. 1—RIENSCH-WURL SCREEN IN SERVICE

To accomplish this, various tank treatments have been devised. Septic tanks, plain sedimentation, and more recently Imhoff or Emscher tanks have all had more or less vogue with engineers and have all proven to have more or less objectionable features, or to develop such objectionable features under conditions of service. In consequence of this the demand has been growing for an immediate system of treatment that would provide for the recovery as a by-product of the values contained in sewage, and be also suitable for like purposes in the industrial field.

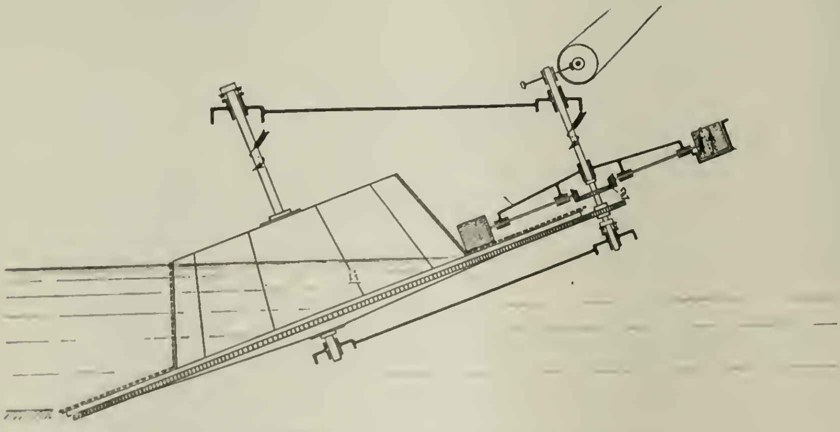


FIG. 3—ELEMENTARY OUTLINE OF RIENSCH-WURL SCREEN

The Riensch-Wurl rotating self-cleaning disc screen has proven a mechanical device capable of successfully accomplishing the desired results. This screen has been developed in Germany as a result of persistent experimenting to produce a fine screen that would automatically clean itself as well as collect a very large amount of the floating and suspended matter in the sewage and deliver the screenings in a sufficiently dry condition to be readily handled with a spade or conveyor system.

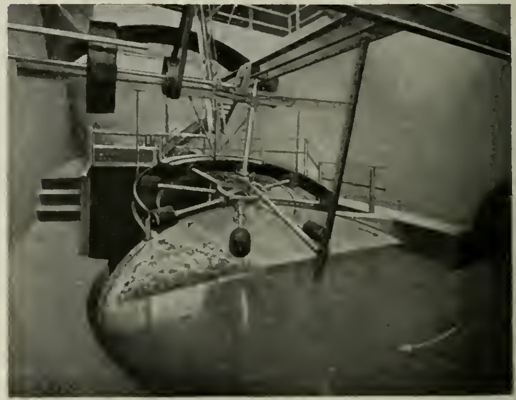


FIG. 2—RIENSCH-WURL SCREEN IN SERVICE

The screen consists of a perforated disc, set at an angle of 10 deg. to 25 deg. to the flow of the sewage, and revolving slowly on a shaft normal to the disc. The solids carried to the screen collect on it and are carried above the surface of the sewage by the rotation of the disc and there allowed to drain, after which the face of the disc is swept by a set of revolving brushes carried on a "star" driven by a shaft parallel to the shaft of the disc. As each portion of the screen surface is swept five or six times by the brushes the result is a thorough cleaning of the screen plate. These screens are made usually with apertures of 2 mm. (5/64 in., or 79 mils) wide by 30 mm. (1 3/16 in.) long, but are sometimes furnished with apertures or slits 1½, 1, or even ¾ mm. (59, 39, 29½ mils) wide.

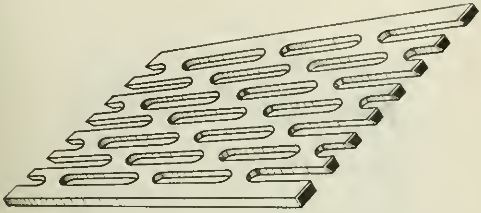


FIG. 4—SECTION OF RIENSCH-WURL SCREEN

The general appearance of this screen is shown in Fig. 1, while Fig. 2 shows a screen in which the central conical screening surface is omitted, but the method in which the screen operates is clearly shown.

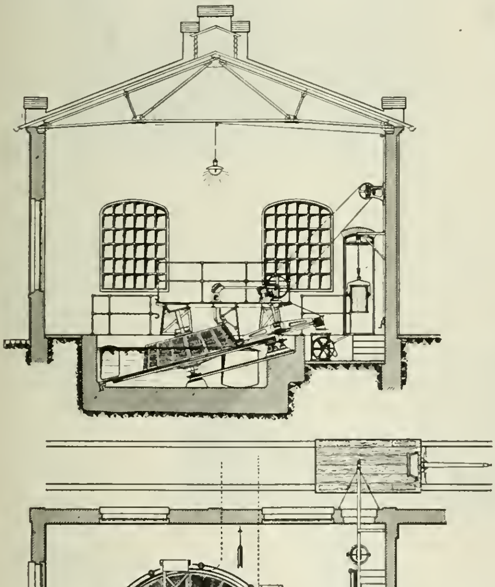


FIG. 5—TYPICAL INSTALLATION OF RIENSCH-WURL SCREEN

The arrangement of the machine will be better understood from the drawing, Fig. 3, while the screen plate is shown in Fig. 4, the tapered openings of which are varied to suit the particular requirements of service to be rendered.

Figs. 5 and 6 are typical installations of the screen alone and with pumping plant, while Figs. 7 and 8 show interior view and layout of the sewage treatment plant at Dresden, Germany, containing four screens, 8 meters in diameter.

The Riensch-Wurl screen is now being introduced in this country by the D'Olier Centrifugal Pump & Machine Company, of Philadelphia, after an extended stay of Mr. William L. D'Olier in Europe, where he studied and invesigated foreign sewage-disposal apparatus and processes.

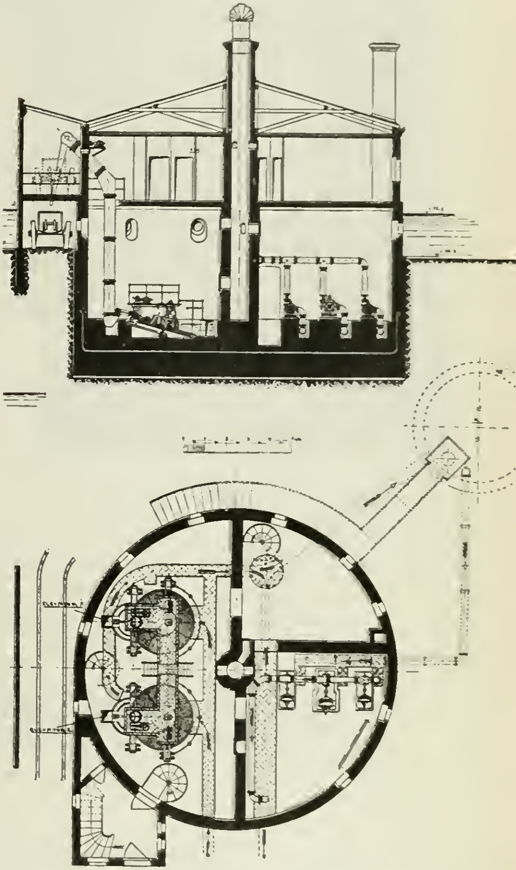


FIG. 6—TYPICAL INSTALLATION OF RIENSCH-WURL SCREEN AND PUMPING PLANT

The Riensch-Wurl screen is not only successfully and satisfactorily clarifying sewage and producing an effluent which is permitted to be discharged directly into the public waters of European countries, but is also removing the solids in the form of so-called sludge with such a minimum content of water as to render this easily handled and transported and in such a condition as to insure a maximum recovery of by-product in grease and degreased sludge, insuring actual financial returns from the operation.

In the process of handling sludge from various tanks, drums and from the Riensch-Wurl screens, a further reduction in water content is necessary, and a continual effort has been made to produce a machine which would successfully accomplish this service. In Fig. 9 is shown a sludge reduction machine, capable of reducing from 98 or less percentage of water to approximately 55 per cent, greatly facilitating the final disposition of handling or reworking of the sludge.

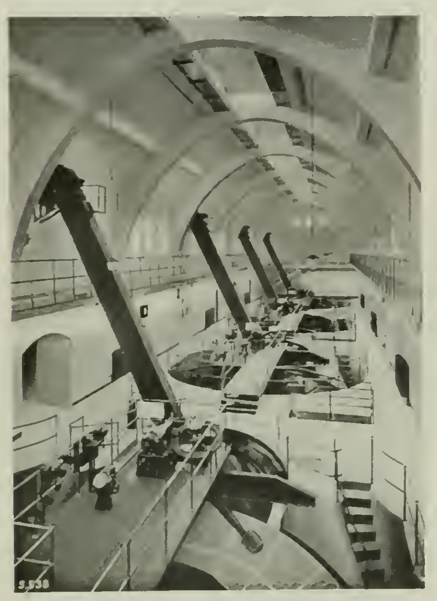


FIG. 7—INTERIOR OF DRESDEN SCREENING PLANT SHOWING FOUR RIENSCH-WURL SCREENS

The perfection and adaption of these machines renders the mechanical treatment of sewage entirely feasible and designs are now under way for a number of plants in the United States.

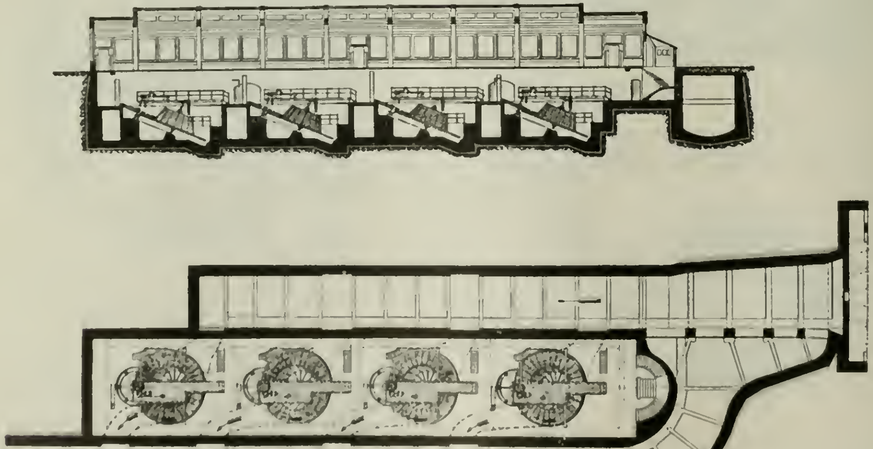


FIG. 8—PLAN OF DRESDEN SCREENING PLANT

The broader application of these screens in various industries should be appreciated with their growing use in the sewage disposal field. Wherever it is necessary to remove the solids from a large content of water, and where a process of screening is required, whereby the screening surface shall be continually kept clean and prevented from clogging the Riensch-Wurl screen should be found useful. Such industries as tanneries, slaughter houses, breweries, abattoirs, beet-sugar factories, pulp and paper mills, woolen mills, bleach works, and numerous other industries, should find in it, not only a simple method of recovering as a by-product, values formerly lost, but these industries would thereby be enabled to anticipate the growing demand for the protection of the streams by the clarification of the waste water from these industries before it is allowed to enter the waters.

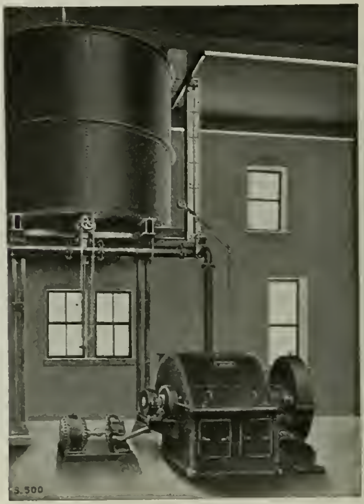


FIG. 9—D'OLIER SLUDGE REDUCTION MACHINE

## Apparatus for Determining the Hardness of Metals by the Brinell Method

The hardness can be determined in different ways. The simplest consists in cutting the metal to be tested by another metal or in determining the pressure which must be exerted on a diamond when cutting a smooth surface by passing it across the surface of the metal under test. Thus the file is often used to ascertain the hardness of steel.

However, these are distinctly laboratory methods; they require a well-polished surface and the use of the microscope, and are slow. Like the use of the file, moreover, they are not sufficiently reliable, the results depending on whether the file used is more or less blunt or sharp.

The Brinell method does not present any of these disadvantages. Brinell impresses a ball of hardened steel into the metal to be tested under a given pressure. He measures the diameter of the indentation made by the ball and determines the area of the spherical cup thus formed. By dividing the pressure exerted by the area he obtains what he calls the hardness number.

The same ball being pressed into different steels under the same unvarying pressure will embed itself to a different degree, thus determining in a regular manner the hardness of the piece. It is easy to read the impression of 1 mm by means of an ordinary magnifying glass, and one can say that each tenth corresponds to a given degree of hardness. The effect on the hardness of steels of different quenching agents for the same temperature, or for different temperatures, can thus be easily followed. It is even possible to determine the uniformity of a treatment by repeating the test in different places. Moreover, this test can be very quickly made—in less than one minute—on the finished product, without injuring same and without the necessity of making test pieces from the part.

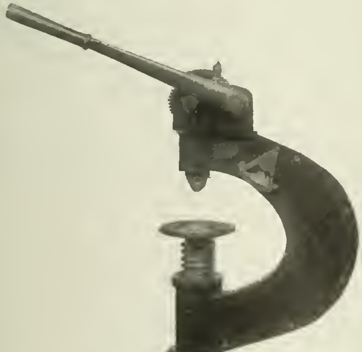


FIG. 1.—HARDNESS TESTING MACHINE READY FOR TEST

The advantage of the ball test is at least just as great when testing case-hardened pieces.

A very convenient apparatus for applying the Brinell method is the Derihon portable hardness testing machine, by which an impression is made with a 10-mm ball under a pressure of 3000 kgs.

Fig. 1 shows the machine ready for the test with the lever raised and resting on the shaft. The piece to be tested is placed on the table of the machine, which is then raised until the piece is in contact with the ball. This done, the lever is pulled slowly over so as to give a progressive pressure (the pressure is registered by a small manometer) until 3000 kgs are applied. When this figure is reached the lever is slowly returned to its former position and the test is completed.

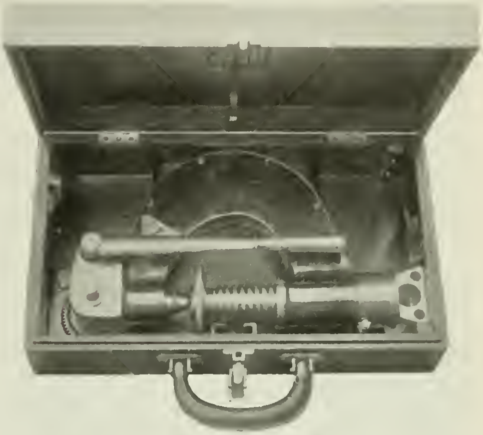


FIG. 2.—PORTABLE HARDNESS TESTING MACHINE

Under normal conditions it is usually sufficient to move the lever through an angle of 45 degrees to obtain the required pressure of 3000 kgs.

With each machine a small piece of steel is furnished in which a standard impression has been made, the size of the diameter being stamped on the same. This standard piece is of BND steel, an air-hardening chrome-nickel steel.

The accuracy of the machine can be easily controlled by making an impression alongside the standard impression.

The construction of the machine is based on the principle of elasticity of the frame, which for this purpose has been given the shape of a horseshoe.

The power produced by the pressure of the ball on the test piece has a tendency to open the frame to a certain degree in proportion to this power. The shape of the frame has therefore been specially considered in order to have it as elastic as possible.

The pressure exerted of 3000 kgs does not at all change the resistance or elasticity of the frame seeing that it is made of BND steel, having an elastic limit of 242,000 lbs. per sq. in., and that a pressure of 3000, 4000 or 5000 kgs does not work it above 10 kgs per sq. mm. (1442 lbs. per sq. in.). Under these conditions repeated tests even in large numbers do not alter at all the calibration of the machine.

The deflection of the frame being relatively weak (1 to 1.5 mm.), a register, the construction of which resembles a metal manometer, is installed in the hollowed-out part of the frame.

By means of a needle and a graduated dial the deflection and, therefore, the pressure exerted on making the test can be quickly and easily read.

To adjust the machine all that is necessary is to open the case enclosing the mechanism above the frame.

Should the machine ever get out of adjustment a comparison should be made on the standard piece, and when an impression of the same diameter has been made the needle is brought over the figure 3000 by means of a small adjusting screw.

This adjustment, however, would only be necessary through some accidental cause independent of the operation of the machine under normal usage.

Fig. 2 shows the machine packed in its portable case. This machine is placed on the market by H. A. Elliott, 507 Majestic Building, Detroit, Mich.

## Anti-Corrosion Pickling Chains and an Acid-Pump Casting

The life of forged chain used for handling material in pickling baths varies for the part submerged in or subjected to the action of the acid and fumes from eight days in the most exposed locations to a possible month under favorable conditions. Many methods of treating such chains have been tried out, but all externally applied protectors broke or wore off at the point of contact of the links, and added but little to the life of the chain.

TWIN-CYLINDER CASTING FOR ACID PUMP

Substitution of special acid metal chains for the iron ones was proposed, and found to give perfect satisfaction. Many of these chains have been in service for periods of from two to four years and have needed repair only when worn out.

Casting of such a chain offered many difficulties on account of the size, and the tendency for the links to cast solid. At the Morgan Engineering Co., Alliance, Ohio, where chains of this kind are now made, a four-quarter mold, built up of core sand and baked, has finally been designed. The alternate links were cast separately in ordinary molds and finished before being fitted into the molds for connecting, and the joining links cast around them. This method insures sound links and obviates the forming of blow holes found when it was attempted to cast the chain at one pouring.

The subjoining illustration shows a twin-cylinder casting for an acid pump made in the foundry of the same company. This casting is of unusual size and complexity and was the first of a lot of three pumps for handling large quantities of diluted acid and dirty water.

The casting required metal from three crucibles and when thoroughly cleaned up weighed 1680 pounds. No blow-holes or other irregularities were encountered in cleaning up the casting, and it was found that the metal averaged closely to the same analysis throughout, showing that the three meltings were the same and the heats similar. All the mechanism of the pump is to be of the same acid-resisting metal, preventing any damage to the pump through corrosion.

## Weighing and Regulating the Continuous Flow of Materials on Conveyors

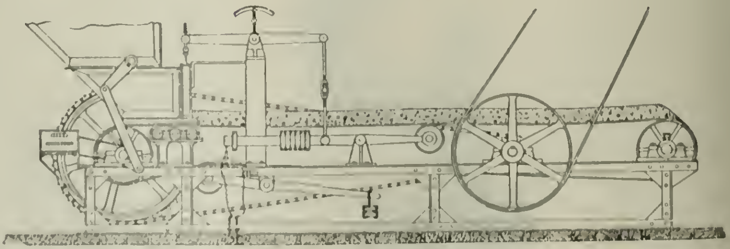
The adjoining illustration shows the Schaffer poidometer, built by the Schaffer Engineering & Equipment Company, of Tiffin, Ohio. This machine weighs and regulates the flow of materials traveling in a continuous stream over a conveyor. It can be attached to a hopper, bin or elevator spout, and delivers the material in any predetermined quantity at an even, regular flow, and records the amount handled, regardless of changes in specific gravity, amount of moisture or size of materials.

An interesting application of this machine which indicates the wide limits of its possibilities is in a clay products factory, where it adds manganese in proportion of one-half of 1 per cent and delivers the material at the rate of 2 lb. per minute.

The machine consists essentially of an endless belt traveling over pulleys and idlers similar to the method used in regular conveyors. One of these pulleys connects to the regulating and recording mechanism at the bottom of the containing bins.

In cases where it is desired to mix a number of different materials there is provided one machine for each of the materials, and each machine will deliver the desired proportions in a constant stream and insure an even mixture. This machine may also be used to advantage where moisture is to be added to materials in certain quantities.

When materials are put up in batches a special attachment is provided which controls the machine for any desired amount, and when the desired quantity has been delivered the machine automatically stops and again sets itself in operation at the proper time.



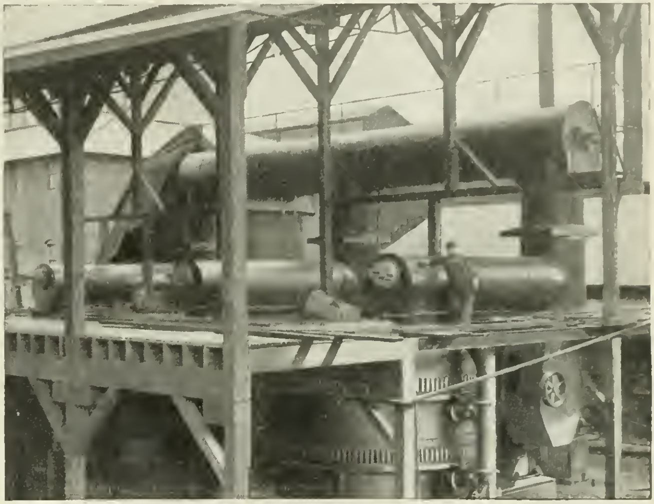
MACHINE FOR WEIGHING AND REGULATING THE CONTINUOUS FLOW OF MATERIALS ON CONVEYORS

The materials handled by this machine should be either in powdered or granular form, but a certain percentage of large lumps, up to 1¾-inch mesh, does not interfere with the proper performance.

## The Application of Producer Gas to Glass Factories

For the past two years the Chapman Engineering Company, of Mt. Vernon, Ohio, have been making a special study of the application of producer gas to the glass-making industry. The problem, viewed from a practical standpoint, presented two phases for study—the generation of a suitable gas and its proper combustion in the melting furnace. It became evident early in the investigation that efficiency in combustion was largely dependent upon a supply of gas uniform in quality and quantity. In other words, the gas producer was the vital factor in the problem, and in its correct design lay the real secret of successful use of producer gas in glass-making.

The demand for uniformity was met with their standard 10-ft. furnace-type producer. In this type fuel is fed continuously from a chamber so placed that it lets the fresh coal sink down on to the firebed, as the latter requires it, and in amounts exactly proportional to the needs of that part of the bed passing beneath the chamber at the time the coal is fed. The result is a perfectly leveled firebed at all times. In addition to this automatic leveling, uniformity of texture of the firebed through the body of the producer is obtained by means of a twisting action imparted to the firebed by revolving the upper and lower portions of the producer at different speeds. The function of this twisting effect is to close up incipient blow holes.


INSTALLATION OF THREE CHAPMAN GAS PRODUCERS

This method of feeding and agitation is radically different from the older schemes of intermittent firing, with consequent rush of gas immediately after each dumping of coal. Not only is the supply of gas from the Chapman producer uniform, but the quality is maintained constant.

Another feature which makes for uniformity is the continuous removal of the ash. This is accomplished by a device as ingenious as it is simple. The ash-removing mechanism includes an ash crusher, which grinds up the larger pieces of clinker that may be formed. The operation is entirely automatic, so that once it is set for the percentage of ash in the coal used it needs little attention beyond wheeling away the ejected ash.

Previous attempts to use producer gas for glass-making have met with much annoyance from the large amounts of soot which collected in the flues, and necessitated frequent shutdowns for removal. The Chapman Engineering Company attacked this problem from two points of view—repression and disposal during operation.

In the matter of repression, the small amount of soot is one of the features of the Chapman producer, which results from the unique method of fuel feed. The Chapman Company has originated a method of burning the soot in the flues without opening up the doors of the flues, as in the usual Sunday "burn-outs." This is done by means of an air blast introduced at regularly spaced intervals along the line of the flues. To a certain extent this method of soot elimination conserves the heat, otherwise lost, which results from the combustion of this much carbon (in the form of soot).

## Pneumatic-Type Recording Tachometer

The field of usefulness of recording tachometers is almost unlimited because there is a great need for measuring and controlling the revolutions of shafting, machinery, engines, etc. In some processes in mills it is desirable to have a certain speed or rate of revolutions maintained continuously or certain stops made periodically, but not too often, and the recording tachometer provides the superintendent or manager with information about the actual operating conditions maintained. For instance, blast-furnace blowing-engines are driven at a certain predetermined number of revolutions per minute, but are usually slowed up once every four hours at casting time.

Bristol's pneumatic-type recording tachometer has been developed to meet such requirements. It is now extensively used in connection with blast-furnace blowing engines for recording the speed of paper machines, etc.

In many instances it is not convenient to have a recording tachometer installed in self-contained form and located near the revolving shaft. One of the special features of the new Bristol pneumatic-type recording tachometer is the flexible connecting tube 25 ft. long or longer between the revolving mechanism and recording instrument which is mounted in any convenient position, as, for instance, on a switchboard or the wall of engine room.

The patent on this pneumatic recording tachometer was issued on July 30, 1912, to Prof. Wm. H. Bristol, and these tachometers, as shown complete in Fig. 1, have now been perfected for use under ordinary shop conditions. Some of the first models of this new tachometer have been in successful service for more than 2½ years.

The pneumatic principle of operation depends on the centrifugal action of air in a revolving tube which is connected on the recorder through a special oil seal and flexible connecting tube.

Fig. 2 shows diagrammatically the construction of the revolving mechanism. B designates a hollow circular protecting base and at its upper surface is provided a bearing for a hollow shaft D. This shaft is arranged to be rotated from any desired mechanism through a set of gears and pulleys (or sprockets).

A pulley C is shown over which a belt runs to a similar pulley attached to the shaft whose revolutions are to be measured and recorded. In practice most of these tachometers are being furnished with special form of sprocket and chain instead of pulley and belts.

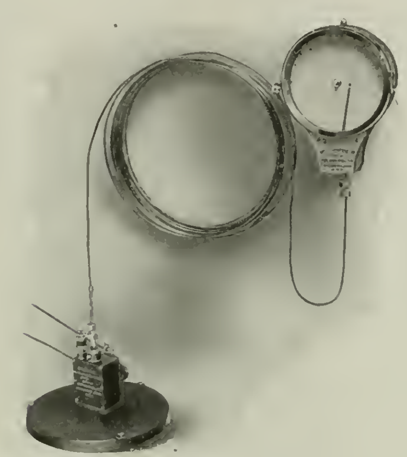


FIG. 1.—PNEUMATIC-TYPE RECORDING TACHOMETER

The lower end of the hollow shaft D, terminates in a horizontal tube A, open at its extremities. The upper end of the hollow shaft is surrounded by a casing E. It is partly filled with oil and into this extends the free end of another tube F. The tube F is stationary and is joined at its outer end to a flexible capillary connecting tube G, leading to the recording instrument.

The recorder used with this patented speed measuring device is a special low-range Bristol recording vacuum gauge. The recording instrument may be installed either near to or at a distance from the shaft or engine, the speed of which is to be recorded, and a suitable length of flexible copper tubing is furnished to connect the recorder with the revolving tube.

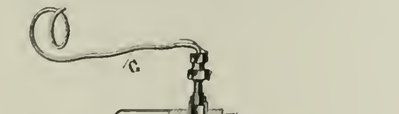


FIG. 2.—DETAILS OF REVOLVING MECHANISM

These tachometers are manufactured by the Bristol Company of Waterbury, Conn., who also manufacture electrical tachometers.

## Chart Recording Instrument

The Brown Instrument Company and the Keystone Electrical Instrument Company, of Philadelphia, Pa., are placing on the market a new continuous recording instrument for use as an electrical pyrometer for recording temperatures, and also as a recording voltmeter or ammeter. The clock mechanism is placed behind the record chart instead of to one side, and the record chart is the only part shown on the face of the instrument.

A two months' roll of record paper is used, which can be supplied with an ink ribbon to make a dotted ink record, or the record can be made on coated paper, which does away with the use of ink or ribbon entirely. It is only necessary to wind the clock once a week and change the roll of record paper once every two months.

Fig. 1 shows the instrument with a 10 hours' record on the recording chart. One scale is placed above the record so that the indications are clearly visible at all times, and the paper has the scale printed on it for direct reading. The instrument is shown with the door open so that the interior construction can be seen. This case need only be opened once every two months to renew the roll of paper.

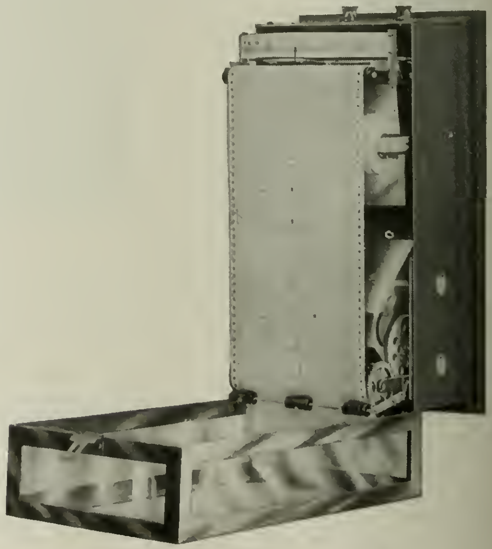


FIG. 1.—CHART RECORDING INSTRUMENT

This continuous recording instrument is intended to be used particularly as an electric pyrometer in conjunction with thermo-couples, or with resistance thermometers for measuring low temperatures, or for recording volts or amperes. The d'Arsonval type of direct-current instrument is used, of the frictionless type, to prevent lag in the readings and secure a sensitive and accurate instrument.

---

The El Ore Mining & Milling Company, of Elkton, Colo., state that weather conditions permitting they will start work on their new 300-ton milling plant about the middle of March, and invite correspondence from mining machinery manufacturers who may wish to take a contract on the building of the plant as a whole, or in part, according to the specifications which the company will be prepared to furnish to manufacturers or contractors.

## Electric Steel Melting

Mr. John A. Crowley, president of the John A. Crowley Company, of New York City, recently returned from England, having successfully concluded negotiations abroad for the exclusive representation of the Grönwall electric steel making furnace for this country.

The inventor is perhaps better known in this country in connection with the ore-smelting furnace of the same name which has had such noticeable success in smelting the Swedish ores, but his steel-melting and refining furnace has now been brought to a stage where it is being successfully operated in several of the English mills, and is also being introduced in the Sheffield section.

The Grönwall furnace is well adapted to either melting cold charges or refining from the molten metal as it is a two-phase type arc furnace with a neutral return fixed in the bottom of the furnace under the lining. Each phase of a two-phase circuit being connected to one of the vertical electrodes, which method forms independent arcs, insures a steadier running than if both arcs were in series, and noticeably reduces the instantaneous jump of the current from 50 per cent under load to 100 per cent over load, especially in melting from cold charges, and also produces a vertical as well as horizontal circulation in the metal bath. The neutral return is level with the brickwork at the bottom of the furnace and does not project or weaken the lining of the hearth, nor is the molten metal subject to any reaction on account of this neutral return. The electrical features of this furnace were described in detail and discussed in an article in our issue of November, 1911 (Vol. IX, p. 573).

The furnace is of the tilting type, permitting the withdrawing of the slag at any stage of the refining process and the introduction of another slag, and also permits the withdrawing of any part or all of the charge at any time.

The John A. Crowley Company will install one of these furnaces as soon as a suitable location can be secured. They will first aim at the production of higher grades of alloy steels for commercial purposes, but the production will not be entirely limited to this class of material, but will include the high-carbon tool and spring steels. Considerable attention will also be given to producing a high-grade steel for castings, for which line of work the furnace is particularly adapted.

## The Non-Ferrous Metal Market

The metal markets for copper, tin, lead and spelter have been without particular feature, and only slight changes have taken place in prices. Fluctuations in price have followed closely the changes in demand and while the tendency has been upward the higher prices have not always held in the face of lessened demand. Producers have been willing to make concessions and buyers have not taken more than enough to meet immediate needs.

**Copper.**—While the export market has been good the domestic demand has been variable. European stocks continue to decline in the face of heavy exports from this country. Local demand is considered to be improving slowly but steadily. Electrolytic copper is quoted at 14.60@14.70, and Lake at 14⅞@15⅛ cents.

**Tin.**—The tendency of prices in this market has been upward, and domestic demand has improved. A slight premium has obtained for immediate delivery.

**Lead.**—The American Smelting & Refining Co. raised its New York price to 4.15 cents on February 11, but reduced it again when the demand slackened. St. Louis lead prices have been above the New York parity. At last available reports the market has slumped decidedly, and New York lead is offered at 4 cents, with St. Louis at 3.90@3.92½ cents.

**Spelter.**—This market has been quiet, with a fair demand for metal. The tendency of prices is upward, New York spelter being quoted at 5.40@5.45 cents, and St. Louis at 5.25@5.30 cents.

**Other Metals.**—Business in aluminum has improved, but is still quiet. New York quotations are 18¾@19 cents per pound. Prices for antimony are firm and various brands are quoted at from 6 to 7.35 cents. Improvement also is noted in the quicksilver market, New York price being $39 per flask of 75 lb. San Francisco quotes $38.50 per flask.

## Personal

Dr. **F. G. Cottrell**, of the Bureau of Mines, has been engaged in the installation of apparatus for fume recovery at Anaconda.

Dr. **Rudolf Gahl** is making metallurgical investigations for the Inspiration Copper Company in Arizona.

Mr. **Ulysses A. Garred** has resigned his position at the Washoe smelter, Anaconda, Mont., and will go to Queensland where he will be with the Mount Morgan Gold Mining Co. He will be succeeded at Anaconda by Mr. **W. N. Tanner.**

Mr. **H. A. Guess**, formerly manager for the Federal Lead Co., Flat River, Mo., has been appointed consulting engineer for the American Smelting & Refining Co., with headquarters at 165 Broadway, New York City.

Mr. **H. W. Hardinge**, president of the Hardinge Conical Mill Company, has left New York for a six week's trip through Western mining centers.

Mr. **H. C. Hoover**, and his wife, **Lou Henry Hoover**, will be guests of honor at a dinner of the Mining & Metallurgical Society of America in New York City on March 9, at which time they will be presented with the Society's medal for their "Distinguished Contributions to the Literature of Mining."

Mr. **William F. Jahn** has been engaged as superintendent of the new cyanide mill of the New York & Honduras Rosario Mining Co., at San Juancito, Honduras, C. A.

Mr. **J. George Lehman**, vice-president and general manager of the Bethlehem Foundry & Machine Co., South Bethlehem, Pa., has just returned from a business trip abroad. Mr. Lehman spent some time in England and Continental Europe on matters pertaining to the development of acid-resisting iron, and while abroad closed a contract with the Lennox Foundry, of London, for the exclusive selling rights for Tantiron in the United States and Mexico. This acid-resisting metal has been in very successful use throughout Europe for a number of years.

Messrs. **Dorsey A. Lyon** and **Robert M. Keeney**, who have been stationed at the Pittsburgh laboratory of the Bureau of Mines, have been sent to Salt Lake City to start the cooperative federal-state work at the School of Mines of the University of Utah.

Mr. **Richard S. McCaffery** has been appointed professor of metallurgy in the University of Wisconsin. For the past few years he has held the position of professor of mining and metallurgy in the University of Idaho.

**Mr. H. P. MacGregor** has opened a laboratory for industrial and engineering chemistry at 535 First National Bank Building, in Denver, having recently severed his connection with Mariner & Hoskins, Chicago.

**Mr. Richard K. Meade**, Mechanical and Industrial Engineer, 202 North Calvert Street, Baltimore, Md., has just completed plans for a new coal pulverizing plant for the Pennsylvania Salt Manufacturing Co. This plant is designed to furnish coal for heating nodulizing furnaces. The plans call for a building of steel, 30 x 90 ft., and all the stairs, runways and galleries are to be of steel. No wood is to be used whatever in its construction. The equipment will consist of a dryer and two pulverizers, together with scales for weighing the coal, elevators, conveyors, etc. All the machinery will be motor-driven.

**Dr. Richard Moldenke** has resigned his position as secretary of the American Foundrymen's Association, but will continue to give his advice and assistance in editing the "Proceedings" of the Association.

**Mr. Richard A. Parker** has been elected president of the Colorado Scientific Society for the current year. Other officers elected were **E. N. Hawkins** and **T. B. Stearns**, vice-presidents; **John W. Richards**, treasurer; **H. C. Parmelee**, secretary; **J. D. Skinner, Charles A. Chase** and **Victor G. Hills**, members of the executive committee.

**Mr. George C. Piwonka** has resigned his position as general sales agent for the Western Chemical Manufacturing Co., Denver, Colo., and will engage in business in Cleveland, Ohio.

**Mr. B. Stanley Revett** is resident general manager of the consolidated dredging properties at Breckenridge, Colo., recently acquired by the Tonopah Mining Co. Mr. Revett was formerly manager for one of the companies that sold to the Tonopah concern.

**Mr. Carl J. Trauerman**, of the metallurgical firm of Rothwell & Trauerman, Butte, Mont., will take charge of the milling operations of the Bully Boy Co., Marysvale, Utah, after March 1.

**Mr. Guy M. Vail**, mining and metallurgical engineer of Portland, Ore., was in Denver recently on professional business.

**Mr. Archer E. Wheeler** has resigned his position as superintendent of the Boston & Montana Reduction Works of the Anaconda Copper Mining Co., to accept a position as consulting engineer to Union Minière de Haut Katanga, which has mining interests in Africa. **Mr. John H. Klepinger**, formerly assistant superintendent, succeeds Mr. Wheeler, and **Mr. Milo W. Krejci**, metallurgist for the company, has been named to succeed Mr. Klepinger.

**Mr. James Wood** has resigned his position as superintendent of the Calumet & Arizona smelter, and will no longer engage in active work.

---

**The sulphur output of Sicily** has shown a steady decrease during the past two working years, according to a recent Consular report. From August 1, 1912, to July 31, 1913, the total production was 351,752 tons, a decline of 15,489 tons, as compared with the previous year. The most striking decline in the exports is that to France, which has always been the best customer. This decline is believed to be due to the establishment of large sulphur refineries in France by the Union Sulphur Co. The Sicilian Sulphur Combine expresses the hope that the steady increase in consumption will permit the Sicilian industry to continue.

## Digest of Electrochemical U. S. Patents

PRIOR TO 1903.

*Arranged according to subject-matter and in chronological order.*

*Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.*

### REFINING METALS *(Concluded)*

669,442, March 5, 1901, Hans A. Frasch, of Hamilton, Canada.

Relates to the extraction of metals from metalliferous substances such as mattes, slags, ores, etc. The metalliferous material is suitably crushed and placed on the bottom of a tank where it is electrically connected as anode. Above this is placed a layer of sand as a diaphragm. An alkaline salt, such as sodium chlorid of 20° Baume strength is the electrolyte. Above the diaphragm are a plurality of cathodes. A plurality of tanks are connected so that the electrolyte flows from one to another in series. In the first and last tank, an overflow is provided from the anode compartment, and a separate overflow from the cathode compartment. In the intermediate tanks but one overflow, from the cathode compartment, is provided. The salt solution is supplied to the first tank and electrolysed, the overflow from the anode compartment passing to the intermediate tanks. In the cathode compartment of the first tank sodium hydroxid is formed, which is removed. In the intermediate and last tanks, copper is deposited from the circulating electrolyte. After leaving the last tank the electrolyte has been freed from copper, and of the remaining metals, iron is precipitated chemically, and the nickel, cobalt, etc., separated electrolytically.

679,824, August 6, 1901, Anson G. Betts, of Lansingburg, New York.

Relates to the electrolytic refining of crude lead, or "work-lead" containing such substances as gold, silver, copper, antimony, arsenic, sulphur, bismuth, nickel, iron, zinc and tin. This alloy is cast into an anode and electrolysed in a solution of about fifteen per cent lead fluosilicate and fluosilicic acid, together amounting to about twenty-five per cent of the solution. Such an electrolyte has a resistance of about two and two-tenths ohms per cubic inch. During electrolysis the electrolyte is circulated and the deposited lead is mechanically compressed from time to time, to break down sprouts and to present an even surface. When a sufficiently thick deposit is obtained, it is removed and melted. The cathode is preferably a sheet steel plate coated with lead.

684,049, October 8, 1901, Elmer G. Elliott and Valentine Kishner, of Perth Amboy, New Jersey.

Relates to apparatus used in refining metals. In practice the anode plates often come from the casting furnaces more or less distorted; also during operation some of the plates will bend or buckle. This invention consists in providing each tank with one or more series of insulating-pins which are mounted upon a movable support and connected to suitable manual operating devices. The pins are interposed between the plates where needed to mechanically separate them. The pins may vary in length and in location in the tanks.

687,800, December 3, 1901, Arthur L. Walker, of Perth Amboy, New Jersey.

Relates to a plant for electro-refining, and is an improvement in the conductors used to carry the current. It consists in placing a conductor plate or strip between two tanks, so that the cathodes of one tank and the anodes of the next are electrically connected. By this means the investment in conductors to carry the current from tank to tank is reduced at least eighty-three per cent over the former practice.

694,699, March 4, 1902, T. Ulke, of Sault Ste. Marie.

Relates to the refining of composite metals such as nickeliferous-copper material. In practice it is advantageous to use a material containing not less than twenty per cent nickel and eighty per cent copper, using a circulating electrolyte of sulphate of copper and nickel. During electrolysis, a certain amount of electrolyte is regularly withdrawn and replaced by copper sulphate solution. The copper deposit is by this means obtained under substantially uniform conditions. To the withdrawn solution is now added either ammonia or ammonium sulphate, thereby precipitating the nickel as nickel-ammonium sulphate crystals which may be purified by further crystallization. The nickel salts are then separately dissolved, the solution made alkaline with ammonia, and electrolysed. From time to time a portion of the impoverished electrolyte is withdrawn and used to precipitate the nickel crystals from the copper solution.

687,831, April 15, 1902, Hans A. Frasch, of Hamilton, Canada.

Relates to refining mattes, etc., and electrodepositing nickel. Refers to his prior patents 669,441 and 669,899. The apparatus preferably used is a series of tanks the bottom of which is covered with broken matte, etc., above which is placed a layer of sand to act as a diaphragm. A solution of sodium chlorid, 20° Baume, is added to the tanks until it comes through the sand diaphragm. Each tank has double inlet and outlet tubes, one of each below the diaphragm for the circulation of the anolyte, and one of each in the upper part above the diaphragm for the circulation of the catholyte. As catholyte, an ammoniacal solution of a nickel salt is used. The two solutions are circulated either continuously or intermittently. Nickel is deposited on the cathode, while the anolyte dissolves the metals in the matte, etc., as chlorides. The solutions do not mix with each other, the heavy chloride always remaining below the diaphragm.

713,277, November 11, 1902, Anson G. Betts, of Lansingburg, New York.

This patent was subsequently reissued as "Reissue 12,301." It relates to an improvement in the electrodeposition of lead by the process described in his earlier patent 679,824. The improvement consists in the addition of a reducing agent, such as gelatin, pyrogallol, resorcinol, saligenin, ortho-amido-phenol, hydroquinone, and sulphurous acid. Phenols of the aromatic series are well adapted for use in this process. It is preferred to use gelatin in the proportion of one part to about five thousand of solution. By the process the mechanical treatment of the lead described in the earlier patent is avoided, the deposited lead being compact and having a specific gravity of about 11.36. A current strength of ten to twenty amperes per square foot of cathode surface, and a corresponding E. M. F. of 0.15 to 0.35 volts for each element is used. With higher currents the lead becomes harder and more brittle.

713,278, November 11, 1902, Anson Gardner Betts, of Lansingburg, New York.

This patent was subsequently reissued as "Reissue 12,117." It relates to the refining of lead and refers to his prior patent No. 679,824. This patent has substantially the same subject-matter as the patent 713,277, but claims the product produced by the process claimed in 713,277.

714,861, December 2, 1902, David H. Browne, of Cleveland, Ohio, Assignor to The Canadian Copper Company, of Cleveland, Ohio, a Corporation of Ohio.

Relates to refining copper-nickel alloys. The material is cast into anodes, and part also into fragments; the latter put into a shot tower and treated with a current of chlorin gas and a shower of sodium chlorid. The fragments are dissolved, forming a solution of cuprous and nickel chlorids. This solution is passed through an electrolytic cell in which the copper is entirely removed, using the copper-nickel anodes and sheet metal cathodes. The outflowing nickel chlorid is treated with an alkali to precipitate the iron, leaving the nickel chlorid pure. This solution is now electrolysed, the chlorin evolved at the anode being used to treat the copper nickel fragments in the shot tower.

The nickel deposited upon the cathode is substantially pure.

---

## Book Reviews

**Chloride of Lime in Sanitation.** By **Albert H. Hooker**, Technical Director of the Hooker Electrochemical Company. Octavo (14½ x 22½ cm.), 231 pages; price $3.00. New York: John Wiley & Sons. London: Chapman & Hall, Limited.

The author acknowledges that Dr. L. H. Baekeland advised and inspired the writing of this work, which may be considered as a means of propaganda for sanitation in general and for the makers of bleaching powder in particular. Seven chapters describe respectively the manufacture and properties of the material in question, its uses for water purification, disinfection of sewage, street sprinkling and flushing, general sanitation (including use in epidemics), farm purposes, and killing the house fly. These occupy about one-third of the book, the other two-thirds being a compilation of abstracts and references on all of the above topics, either reproduced as a whole or carefully condensed. Mr. Hooker and his staff have made a timely and carefully-written contribution to an important branch of medical chemistry.

* * *

**Laboratory Experiments in General Chemistry.** By **H. B. North**, D.Sc., Associate Professor of Chemistry in Rutgers College. 12mo. (19 x 12½ cm.), 205 pages, 36 illustrations. Price, $1.00 net. New York: D. Van Nostrand Company.

This book describes 500 experiments, to be performed in connection with seeing a series of experimental chemical lectures, and using a good text book. From these, selections can be made suitable for varying classes of students. The experiments are excellently chosen, very clearly stated, necessary precautions to avoid danger given in italics, and attention called to the observations and conclusions in a manner calculated to sharpen the wits and educate the reasoning powers of the student.

The table of melting points of the elements needs up-to-date revision. The use of the atomic weights as whole numbers is to be commended in a work of this kind, as it avoids giving the student a fictitious idea of the quantitative accuracy of his experiments.

* * *

**Industrial Chemistry.** Edited by **Allen Rogers** and **Alfred B. Aubert**, in collaboration with thirty-four specialists. Large octavo 16 x24 cm.), xiv + 854 pages, 340 illustrations. Price $5.00 net. New York: D. Van Nostrand Company.

The volume is intended to represent American methods and processes, being an assemblage of the ideas of recognized authorities in their respective fields. Minor details have been given lesser attention. Theoretical considerations have been introduced only where necessary, but the subject matter is essentially descriptive, with most emphasis on the fundamental principles of the methods employed.

The contents embrace general processes, materials of construction, water supply, fuel, producer gas, boilers, engines, motors, power transmission, the common acids, commercial chemicals, chlorine industries, electrochemical industries (by W. S. Landis), lime, cement, plaster, clay, bricks, pottery, glass, white lead, pigments, oils, paints, iron and steel (by Bradley Stoughton), fertilizers, illuminating gas, coal tar and its products, the petroleum industry, distillation of wood, oils, fats, waxes, soaps, glycerine, candles, laundering, essential oils and perfumes, resins and gums, varnish, sugar, starch, glucose, dextrine, brewing and malting, wine, distilled liquors, textiles, dyes, paper, explosives, leather tanning, glue, gelatin, casein.

The treatment is very unequal; no chapters can be said to be poorly written, but some are much better than others—as was perhaps to be expected. Some important industrial chemicals are entirely omitted; hence the reason for cataloguing above the contents of the book. Such omissions are non-ferrous metals, refractory materials, celluloid, bakelite, enameling, treatment of sewage.

The book is beautifully printed and contains some very well written articles; it can be of great use to the student or manufacturer wishing to familiarize himself with the elements of industrial chemistry.

* * *

**The Electric Furnace:** Its Construction, Operation and Uses. By **Alfred Stansfield, D.Sc.,** Professor of Metallurgy in McGill University. Second Edition. Octavo (14 x 23 cm.), 415 pages, 155 illustrations; price $4.00 net. New York and London: McGraw-Hill Book Company, Inc.

Prof. Stansfield's second edition, revised, enlarged and reset, is practically a new book, and is, at the present moment, the best book in English on the electric furnace. It is very fittingly dedicated to Dr. Eugene Haanel, director of the Canadian Bureau of Mines, who has done so much towards starting electric smelting processes.

The details are carefully and systematically worked out. Particular mention should be made of the five chapters on zinc and on principles of construction and operation. The latter makes use of the recently published data concerning heat conductance of furnace walls and electrodes, and is admirably written. In fact, there is scarcely a chapter in the book which does not deserve commendation.

One disappointment is the bare mention of the "large number" of electric furnaces which have been devised for the manufacture of glass, without any description whatever of these interesting furnaces. Bronn, in *Die elektrische Oefen*, gives a large part of his work to them. The book is suitable alike for students, technologists and the general scientific reader. We congratulate the author on the very useful result of his scholarly and conscientious work.

* * *

**Quantitative Analysis by Electrolysis.**. By A. Classen, with the cooperation of **H. Cloeren.** Translated from the fifth German edition by **Wm. T. Hall,** Assistant Professor, Massachusetts Institute of Technology. Octavo (14 x $22\frac{1}{2}$ cm.), xiv + 308 pages, 51 figures, 2 plates; price $2.50 net. New York: John Wiley & Sons, Inc. London: Chapman & Hall, Ltd.

The present edition may be regarded as practically a new book, since it contains all the improvements in the theory and practice of electro-analysis made in the last decade. The translator has added to the original the Spear and Strahan rapid method of determining zinc. He also uses the notation and symbols recommended by a committee of the American Chemical Society. The skilled electro-analyst will find collected here all the reliable information extant, while the general reader will be astonished at the versatility and applicability of electro-analytical methods. Further yet, the electro-chemist interested in electro-plating, electro-extraction or electro-refining of metals will find therein many items of exact and useful information directly applicable to the problems which he is trying to solve.

* * *

**Electrical Engineering for Mechanical and Mining Engineers.** By **H. J. S. Heather, B.A.** Octavo 13 x 21 cm.), ix + 332 pages, 184 illustrations; price, $3.50 net (9/6d). New York: D. Van Nostrand Company. London: "The Electrician" Printing and Publishing Company, Ltd.

This book contains a series of twenty lectures prepared for and delivered to the resident mechanical engineers of the mines of the Witwaterswand, South Africa. The author was at that time connected with the University of the Cape of Good Hope and the South African School of Mines and Technology.

No attempt was made to impart a general knowledge of electrical engineering, but the lectures were intended to give to the mechanical engineers at the mines the elements of electrotechnics, so that they would be able to understand or possibly to supervise the work of the mine electrician. Any non-electrical engineer wishing to get an intelligent idea of the principles of electrotechnics and of the elements of electrical engineering will find this book helpful and useful.

* * *

**Die Quantitativen Untersuchungsmethoden des Molybdans, Vanadiums und Wolframs.** By **Dr. Hans Mennicke,** Ing. Chem. Six by 10 inches (18 x $25\frac{1}{2}$ cm.), 231 pages. Price, paper, Mk. 8; bound, Mk. 9.50. Berlin: M. Krayn.

Under this title appears a collection of practically all the analytical work along these lines. The methods of analysis are set forth in the order of their importance, based on the accuracy of the results obtained therewith, and on their commercial applicability.

The subject is treated under four heads: (A) introductory; (B) Molybdenum; (C) Vanadium; and (D) Tungsten. The introductory part describes the determination of carbon and sulphur in metals, ferro-alloys, and special steels containing these rare metals. An appendix gives the literature and a factor table.

The three main subjects are treated accurately and satisfactorily. They are properly subdivided, and special stress is put on indicating the work of greatest value for accurate determinations. The methods of analysis of importance are clearly described in detail and one feels that among them may be found methods applicable to any special cases occurring in the analytical, chemical and metallurgical field of these rare metals.

The book is of value as a guide not only to the student interested in the chemistry of the rare metals, but also to the practical man handling the raw or finished products containing molybdenum, vanadium, or tungsten as a constituent, such as ores, salts and preparations, alloys and steels. As the literature on the rare metals is somewhat scattered, this collective work on the subject treated is probably better than anything in print in the English language.

---

**Suit for dissolution** of the American Smelting & Refining Co., under the Sherman act, is being considered by the Department of Justice.

The **Richmond Forgings Corporation,** of Richmond, Va., makers of drop forgings, has opened an office at Detroit, Mich., which for the present will be in charge of Sales Manager Landon C. Wellford, in the Dime Bank Building. Mr. A. O. Knudsen, of Newton Centre, Boston, Mass., will represent the same company in the New England States.

# Metallurgical and Chemical Engineering

A Consolidation of Electrochemical and Metallurgical Industry and Iron and Steel Magazine

Vol. XII New York, April, 1914 No. 4

PUBLISHED MONTHLY BY THE

McGraw Publishing Company, Inc.

James H. McGraw, President.
C. E. Whittlesey, Secretary and Treasurer.
239 West 39th Street, New York.
Telephone Call, 4700 Bryant.
Cable Address, Metchem, New York.

Western Office.................421 Boston Bldg., Denver, Colo.
Chicago Office..........................Old Colony Building
Philadelphia Office................Real Estate Trust Building
London Office.............Hastings House, Norfolk St., Strand

E. F. Roeber, Ph.D., Editor.
H. C. Parmelee, Western Editor.

J. M. Muir, Manager.

*Yearly subscription price for United States, Mexico and United States dependencies,* $2.00; *for all other countries,* $2.50. (*European exchange,* 10 *shillings,* 10 *marks,* 12.50 *francs.*)

Copyright, 1914, by the McGraw Publishing Company, Inc.

Entered as Second-Class Matter at the Post Office at New York, N. Y., under the Act of Congress, March 3, 1879.

New York, April, 1914

CONTENTS.

Editorial:

Central Research Organizations.......... 213
Æsop at Niagara Falls.......... 214
The Steel Corporation's Report.......... 214
Engineering Education.......... 214
The Changing Character of Rail Steel.......... 215

Readers' Views and Comments:

Quotations from Classics. By F. A. J. Fitzgerald and Woolsey McA. Johnson.......... 216
Keeping an Electric Furnace Hot During Periods of Idleness. By Ernst M. Schemelz.......... 216
Efficiency and Refining Possibilities of the Induction Furnace. By Joh. Harden, and C. H. Vom Baur.......... 216
Concentration of Complex Sulphide Ores from the Mary Murphy Mine. By H. C. Parmelee.......... 217
Pyrophoric Alloy Patent Decision.......... 218
The Brown Cyanide Patent Decision on Appeal.......... 219
Presentation of the Bronze Bust of the Late Morris Loeb to the Chemists' Club.......... 220
Program of the New York Meeting of the American Electrochemical Society.......... 221
The Western Metallurgical Field.......... 221
Skin Effect in Carbon Electrodes. By A. T. Hinckley.......... 223
The Electric Iron Ore Smelting at Hardanger in Norway—II. By Joh. Harden.......... 223
Some Notes on Stamp Mill and Milling. By William H. Storms.......... 225
Blast Furnace Blowing Apparatus. By J. E. Johnson, Jr.......... 230
Concentration of Complex Sulphide Ore from the Mary Murphy Mine. By George E. Collins.......... 243
Soot-Fall Study of Pittsburgh. By John O'Connor, Jr.......... 247
A Successful Method of Amalgamating in Cyanide Solution. By John Randall.......... 248
Mechanical Refrigeration—III. By H. J. Macintire.......... 249
The Igneous Concentration of Metallic Values from Mixed Sulphides—I. By F. L. Clerc.......... 250
Hygiene and the Use of Ozone for Ventilation. By Prof. Czaplewski.......... 254
Iron and Steel Market.......... 259
The Non-Ferrous Metal Market.......... 259
Recent Chemical and Metallurgical Patents.......... 260
Synopsis of Recent Chemical and Metallurgical Literature.......... 262
Notes on Chemistry and Metallurgy in Great Britain.......... 263
Coal-Gas Plant and Lime Plant at the Niagara Works of the American Cyanamid Company.......... 265
New Metallurgical Laboratory in California.......... 268
Some Interesting Oil Tests.......... 269
A New Continuous and Dustless Dryer for Sludge Material.......... 272
Duriron Castings for Chemical and Metallurgical Purposes.......... 274
A Small-Size Electric Arc Furnace for Melting and Refining.......... 275
Personal.......... 277
Digest of Electrochemical U. S. Patents.......... 277

## Central Research Organizations

Research is the order of the day in metallurgy. The time was when companies moved along in an even tenor, more satisfied than dissatisfied with their processes, showing little disposition to look for improvements or new ideas as long as they met with financial success. They limited their operations to the treatment of ores readily amenable to comparatively simple processes, and took the cream of mineral production. The number of technically trained men was small, and operations were conducted more by rule-of-thumb. Such were the conditions that inevitably surrounded the inception of the metallurgical industry in the West.

Development in the arts, sciences and technology has been accompanied by a vast increase in the number of trained workers who have the spirit of investigation demanded by the intricate problems that have come hand in hand with the change in economic conditions. To-day no concern of importance rests on its laurels. Research departments are maintained in various degrees of magnitude. Appropriations from earnings are regularly made for the support of investigation. Methods of operation change so rapidly that one is kept busy if he would be in touch with developments from month to month.

All of this represents a state of healthy discontent, and contributes greatly to progress. But the question arises: Is metallurgical research being conducted to the greatest economic advantage? Is progress as rapid under a system in which each company maintains its corps of workers, as it would be if groups of companies engaged in similar pursuits supported a central research organization? Instances could be cited which apparently warrant an answer in the negative, though there is no thought of suggesting that the idea is of universal application.

Consider, for example, the research work of the established copper companies. A half dozen could be promptly named that are investigating hydrometalurgical and other processes of common interest. Not forgetting that each problem is in some measure peculiar to itself, we presume there must be some fundamental features common to all, which, once solved, would be of general benefit. And yet each investigator is working individually on the same problem. Not only is a great deal of work needlessly duplicated, but time and money are consumed without profit. Perhaps several men carry on investigations to the same point and then abandon them. Later, another investigator, not fully informed, repeats all the work and ends at the same point instead of taking advantage of previous work and starting where others stopped.

Of course, the usual objection to centrally organized research is found in individual ambition and professional jalousy. Each wants credit for his work, and fears to lose his identity in a larger scheme. But there might be just as much pride in belonging to a fine organization as in working alone, and the economic results ought to be greater. Even under present conditions there is willingness to "swap ideas," and representatives of the large companies are constantly visiting back and forth, so that some degree of benefit accrues from the interchange of knowledge. But even so, there is much duplication of work and unproductive experimenting for which the industry pays several times instead of once. Separate research departments have proved valuable. May not central organizations be the next economic step?

### Aesop at Niagara Falls

Our friend the *Mining and Scientific Press* of San Francisco, writes as follows:

"Much as we admire our brilliant contemporary, *Metallurgical and Chemical Engineering*, we cannot accompany it on its forays into the realms of natural history. Recently it sought to illustrate the present situation at Niagara Falls by means of a fable in which a beaver and an eagle enter into an agreement to divide the fish they catch, an arrangement which worked admirably until a tiger appeared and demanded a share of the spoil. Possibly the metamorphoses effected by the metropolitan fur dealers, who without difficulty transmute a raccoon into a Hudson seal, have so bewildered the New York editor that he confuses a beaver with an otter and an eagle with an osprey, but where does the tiger come in? Fortunately Mr. Theodore Roosevelt is still in South America and the life of the nature-faking chemical engineer is therefore not in immediate danger, but we advise him to accept an engagement which will take him to the Lena goldfields, or some equally inaccessible place, at the earliest possible moment."

We have heard of a fox with an appetite for grapes; but East is East and West is West, and fish stories are not understood by some people.

### The Steel Corporation's Report

The United States Steel Corporation began business April 1, 1901, so that the report for 1913, just issued, covers its twelfth full calendar year. The 1913 earnings, $137,181,345, make the best showing for a year with but three exceptions, 1906, 1907 and 1910. The tonnage of steel products measured in the form in which sold, 12,374,838 tons, stands second to that of but one year, 1912, and is only 1 per cent below the total for that year. The earnings per ton in 1913, $11.09, are naturally less than in any of the three years in which total earnings were larger. They are indeed smaller than those of eight of the twelve years, viz., 1902, 1903, 1905, 1906, 1907, 1908, 1909, and 1910, and they exceed those of 1911 by only 8 cents.

Thus the Steel Corporation has in its twelve years of life somewhat increased its total earnings, while it has greatly increased its tonnage, and its earnings per ton have very materially decreased. In its last three years its total earnings have been materially greater than in its first three years.

There was a remarkable increase in the Steel Corporation's labor cost in 1913. The comparative figures are as follows:

| | 1912 | 1913 |
|---|---|---|
| Average number of employees | 221,025 | 228,906 |
| Total salaries and wages.... | $189,351,602 | $207,206,176 |
| Average per employee per day: | | |
| Excluding general administrative and selling force ........................ | $2.68 | $2.85 |
| Including general administrative and selling force ........................ | 2.75 | 2.92 |

The total output decreased from 1912 to 1913 by about 1 per cent. Furthermore, the output of sheets and tinplates decreased from 12.8 per cent of the total to 10.3 per cent of the total. Of the important branches, this is the one which employs the largest number of men per ton of output, and of the number employed a large proportion are highly paid tonnage men. It is, therefore, remarkable that the total number of employees increased by 3.57 per cent. The larger increase in total wages and salaries paid, 9.43 per cent, reflects the general wage advance made effective Feb. 1, 1913, which affected about 75 per cent of all employees, giving them advances ranging from 12½ per cent in the case of the lower paid men down to smaller percentages for higher paid men.

Inasmuch as the average degree of finish of the Corporation's output has increased, trustworthy comparisons cannot be made, but it is interesting to note that its apparent wage and salary cost, per ton of output in the form in which sold, was $14.94 in 1902 and $16.76 in 1913, an increase of 12 per cent. Meanwhile the average pay per man increased 26 per cent. Having regard to the higher degree of finish attained in the average ton of product, the manual effort per ton has probably decreased, but only slightly. The remuneration in proportion to effort has probably increased considerably. It is quite possible that the increase in wages received has not fully equaled the increase in the cost of living, but there is the very important fact that the average selling prices of steel have greatly decreased since 1902. Realized prices upon steel were very much lower in 1913 than in 1902. The margin per ton of output has decreased, but interest and dividend payments have been maintained through the production of a larger tonnage.

### Engineering Education

The recent announcement that Harvard University and the Massachusetts Institute of Technology have arranged to combine their forces in support of engineering education, may have a broad bearing on the future of engineering schools in this country. It suggests a tendency toward consolidation or concentration of educational forces, rather than further division and duplication. Universities and colleges are not efficient institutions when regarded from a business point of view. There is too much duplication of plant and staff, frequently accompanied by insufficient resources to make the work effective. This results in a struggle for existence that handicaps the institution and its students.

With this entering wedge already made in the East, it is likely that its effect will gradually be felt in the West and cause a much needed readjustment among western schools. The State largely supports university and college education in the West. In some of the commonwealths there has been a deplorable duplication of work, that puts a needless burden of taxation on the citizens. Colorado, for example, has a State University, School of Mines and Agricultural College, each teaching some branches of engineering. Washington has a State University and State College; Utah, a State University and Agricultural College; Oregon and Montana each maintain two, or, possibly, more, separate institutions, and so on through the list.

In all of these States the legislatures are called upon to appropriate funds for the maintenance and extension of two or more schools; and it seems inevitable that, from purely economic considerations, consolidation and concentration of effort will be forced on western schools. At present there is needless duplication in administration, instruction and equipment, and each institution is constantly, and quite naturally, increasing its demands on the State. The cost of education per student is needlessly high, for attendance is divided and equipment is multiplied.

The example furnished by Harvard and Technology probably will bear fruit elsewhere, East as well as West. From the larger point of view, the idea of consolidation is excellent, even though it entails sacrifice of individuality. The results ought to be a higher standard of engineering and a greater efficiency among future engineers. If western schools can agree on a scheme for cooperation they will have the satisfaction of working out their own salvation instead of having it forced upon them.

## The Changing Character of Rail Steel

A few years ago it became evident that the ordinary Bessemer steel rail was doomed. The statistics of rail production in 1913, made public within the past fortnight, furnish conclusive evidence that alloy-cleared Bessemer steel has so far failed to save the situation for Bessemer steel. It still remains to be seen whether the electric refining process may not save the Bessemer rail. The electric steel rails at present in track have stood very well so far, but it would seem that some reduction in cost of the electric treatment was needed to encourage the railroad companies to become buyers.

In 1909 it became clearly established that the plain Bessemer rail could not survive as anything more than a subsidiary product. In 1907 the proportion of Bessemer to total steel rails was 93 per cent; in 1908 it was 70.3 per cent, and in 1909 it was 58.5 per cent, showing a rapid and irresistible trend. In 1912 the proportion was 34.4 per cent, while in 1913 it had dropped to the almost negligible proportion of 24.4 per cent.

The decadence is still more emphatically shown by the observation that of rails weighing 85 lb. and over per yard the proportion of Bessemer in 1913 was only 12.2 per cent. The standard rail of the future, of course, promises to weigh more than 100 lb. rather than less.

As to alloy-treated steel rails the following statistics of production in gross tons are very illuminating:

| | Open-hearth. | Bessemer. | Total. |
|---|---|---|---|
| 1909 | 13,696 | 35,699 | 49,395 |
| 1910 | 27,389 | 229,935 | 257,324 |
| 1911 | 38,539 | 115,450 | 153,989 |
| 1912 | 40,393 | 108,874 | 149,267 |
| 1913 | 33,567 | 25,952 | 59,519 |

The total of alloy rails was a maximum in 1910, there being a rapid decrease whereby three years later the quantity of such special rails was diminished to less than one-fourth of the 1910 total. Of additional significance is this fact, that while in 1910 practically nine-tenths of the rails alloyed or titanium treated were Bessemer, in 1913 less than one-half of the greatly diminished quantity was Bessemer.

The regular alloy rails are given as manganese, copper and nickel, electric rails being included in the statistics whether alloyed or not. In 1909 there were 35,945 tons titanium-treated, but the statistics do not show the division between Bessemer and open-hearth. Beginning with 1910 the titanium rails are shown separately as to Bessemer and open-hearth, and the figures again show a strong decline for Bessemer rails.

Within a few years the possibility of reviving the Bessemer rail by the discovery of a new process will have been greatly reduced, because the Bessemer equipment, which originally involved the expenditure of millions of dollars, is itself disappearing. One by one the great Bessemer steel plants have been modified, by actually dismantling the converters, by resorting to duplexing, or by the addition of open-hearth furnaces which would supply at least part of the steel for the attendant rolling mills. The last to yield has been the great Edgar Thomson works in the Pittsburgh district, in which plant fourteen large open-hearth furnaces have been installed in the past year.

Last year's total rail production was 3,502,780 tons. While this showed a gain of 5.2 per cent over the previous year, there were three years, 1906, 1907 and 1910, which showed a larger production than 1913, and the largest year of all was 1906, with 3,997,887 tons. Thus in seven years the rail industry has failed to make a new tonnage record. Such a lapse is not a new thing in rail manufacture, for in 1887 there was produced 2,139,640 tons, and it was not until 1899, twelve years later, that a new record was made.

Even the export trade in rails does not make a particularly good showing. It is true, 1913 made a new record, with 460,553 tons to its credit, but as long ago as 1900 there was exported 361,619 tons. Included in the 1913 exports was 161,971 tons shipped to Canada, against only 25,341 tons in 1910.

Rail exports apart from Canadian have really decreased in the most recent years, and it is fairly plain that very large exports to Canada cannot be continued. Canada is building railroads at a rapid rate for the moment, but the demand is probably temporary and it is doubtless for that reason that Canada does not establish sufficient rail-making capacity of her own to supply the demand.

# Readers' Views and Comments

### Quotations from Classics

*To the Editor of Metallurgical & Chemical Engineering:*

Sir:—It grieves me very much to feel compelled to criticise Mr. Woolsey McA. Johnson's article in the current number of your journal. On page 167 Mr. Johnson makes a grossly inaccurate quotation from that great English classic, "Alice Through the Looking Glass." While I fully realize the difficulty of making correct quotations from memory and while errors may be excusable in the case of relatively obscure and inaccessible literature, I fear that if something is not done your pages will shortly be disfigured by incorrect quotations from Shakespeare and the Bible.

Francis A. J. FitzGerald.

*Niagara Falls, N. Y.*

* * *

*To the Editor of Metallurgical and Chemical Engineering:*

Sir:—I have read Mr. FitzGerald's letter. I could have wished that he criticise the article in more important parts. The quotation is as follows:

"The walrus and the carpenter were walking close at hand. They wept like anything to see such quantities of sand. If this were only cleared away, they said it would be grand."

"If seven maids with seven mops swept it for half a year, 'do you suppose,' the walrus said, 'that they could get it clear?' "

My use of the above was, of course, merely in nature of a paraphrase and no pretence to accuracy was made.

Woolsey McA. Johnson.

Hartford, Conn.

### Keeping an Electric Furnace Hot During Periods of Idleness

*To the Editor of Metallurgical and Chemical Engineering:*

Sir:—In my article on the Stassano electric steel furnace at Redondo, Cal., in the December, 1913, issue of this magazine, it was stated that another furnace of the same type was being built in an Eastern foundry. This latter furnace has been in operation for some time at the works of the Hess Steel Castings Co., of Bridgeton, N. J., and results equally as good as at the previous installation are reported.

The furnace is an exact duplication of the one running in California, and we refer to the description and pictures of it in the above-named article in the December issue.

One new and economic feature in the operation of the furnace, however, is of especial interest. Slackness in business made it possible to turn out only one heat per day, and for some time only one heat every other day. The question arose how to keep the basic magnesite lining hot during the long intervals at a minimum expense.

Heretofore the Stassano furnaces running in daytime only have been kept hot nights and during the Sunday idleness by electricity, which method involved a considerable expense for current, electrodes, and labor. In this new installation, however, an arrangement was made to keep the furnace hot by means of an oil burner, cutting down the cost to a small fraction of the former cost for electricity, and entirely eliminating the cost of electrodes and labor, as the oil burner needs no attention whatever. A similar arrangement has been worked out independently for the California furnace.

The small steel foundries, which could not take care of the total output of five tons for 24 hours of the one-ton type of Stassano furnace, or which for some other reason wanted to avoid working a night shift, will be highly interested in the fact that they can now run a furnace of this type in daytime only with two or three heats, at only a nominal expense for heating. In many instances the foundry gains the added advantage of keeping off the peak load of the power company supplying the current, and thereby enjoying a cheaper current rate.

Ernest M. Schmelz.

Detroit, Mich.

### Efficiency and Refining Possibilities of the Induction Furnace

*To the Editor of Metallurgical & Chemical Engineering:*

Sir:—In your February issue, page 74, Mr. Ivar Rennerfelt is good enough to draw my attention to the fact that the original statement in my article "Induction Furnace Notes" of October, 1913, was correct and not an error as stated in the December issue, 1913.

As Mr. Rennerfelt assumes, the expressions "melting hours" and "kilowatt hours" (units) have been mixed up, as I find by looking up the melting records. I, therefore, wish to thank Mr. Rennerfelt for drawing my attention to the mistake.

An *electric* efficiency of 67.1 per cent, however, is certainly not unattainable in a two-ton furnace; I have on record an efficiency of well over 71 per cent in an even smaller furnace having a capacity of only 850 kg.

But it should be borne in mind that the expression "electrical" or "theoretical" efficiency is a very deceiving one.

As is well known generally, steel is not made by simply melting down scrap; even at its best it must also be purified from gases, oxides, etc., and the figure of 63.8 per cent includes all power spent for such purposes.

The *economical* efficiency is, to my mind, the only important factor, as is also emphasized in the subsequent paragraph of the article.

As to the refining question, it is well known and has often been repeated both by myself and others that the *single-ring* induction furnace, with its narrow channel and small bath surface, is not intended to be used for the removal of sulphur and phosphorus, but in many respects it is an ideal melting furnace and is therefore recommended as such.

It was this I had in mind when the statements quoted were made.

The "combination" induction furnace of the Rodenhauser type, however, to which Mr. C. H. Vom Baur no doubt was referring in his article, and which I also have had many opportunities to watch, has very good refining possibilities on account of its enlarged central hearth and larger bath-surface.

So has also the double-ring induction furnace designed by Mr. O. Frick.

It is not my intention to enter into a controversy as to the relative merits or disadvantages of arc furnaces and induction furnaces; both have their fields and if one is asked to recommend one or the other, as is frequently the case, the answer must be made solely with the purpose in view for which the furnace is intended, disregarding any sentiment in favor of one or the other.

Special conditions, as regards the work to be carried out, the locality, the available electricity supply, the question of continuous or intermittent operation, etc., must be carefully considered in each individual case before one is able to recommend one system or the other.

An open discussion, such as Mr. Rennerfelt suggests, would no doubt be of general interest. But it is very questionable whether it would lead to any so-called final decision. Both systems will no doubt continue to live side by side, as past experience seems to indicate.

Only the most careful consideration of each individual case and a full knowledge of the merits and possibilities, as well as the drawbacks and limitations of the various furnace types, will enable the engineer and metallurgist to make up his mind which type is most likely to be successful in his particular case. JOH. HARDEN.

Luton, England.

* * *

*To the Editor of Metallurgical & Chemical Engineering:*

SIR:—Mr. Rennerfelt's communication appearing in your February issue is very interesting. No doubt what Mr. Harden had reference to was a single-ring induction furnace of the Kjellin type. My own experience with furnaces of this kind has confirmed that it is impractical to endeavor to refine steel with the usual slags in a single-ring and narrow-channeled induction furnace.

However, all these furnaces had to have their beginning, and it is now over a dozen years ago that Kjellin first placed an induction furnace in regular commercial operation. It is now over seven years that the first wide-hearthed induction furnace was placed in operation, and one is now under construction with a bath the exact proportions of an open-hearth of corresponding size. The induction furnace will soon be in its early manhood, with the progress now going on.

To return to the refining—as soon as a two-ring induction furnace was placed into practical operation, it was demonstrated that any degree of refining of phosphorus and sulphur and general degasification could be obtained. A curve taken from Rodenhauser's and Schoenawa's book on Electric Furnaces in the Iron and Steel Industry, page 399, shows that the phosphorus dropped from 0.06 to 0.025 per cent. in the first 20 minutes, while the desulphurization was from 0.065 per cent. to traces in somewhat more than an hour. The general deoxidation or degasification is exemplified by the excellent physical qualities of tool steel—about 57 varieties—not to mention rail steel and others, made in the 8 to 10-ton Roechling-Rodenhauser furnace, charged with liquid basic Bessemer steel.

There are as many induction furnaces to-day in Germany as there are arc furnaces, so that favoritism is at least evenly divided, even though the induction-furnace installations are usually more expensive for the same size, than their arc-furnace brothers.

At Kladno, the Poldhihuette after using a 4-ton Kjellin furnace, single-ring type, for about 6 years is installing an improved design of induction furnace of 13 tons capacity. One of the large iron works of Eastern Pennsylvania is installing two 20-ton induction furnaces. Krupp at Essen has two 10-ton induction furnaces in regular operation, so whatever their "practical drawbacks" are, their virtues are enough to overcome them as the repeat orders indicate. The induction furnace is a very rugged child in the electro-metallurgical industry just now, even though it was a little dwarfed in its infancy.

C. H. VOM BAUR.

Douglaston, N. Y.

## Concentration of Complex Sulphide Ore from the Mary Murphy Mine

*To the Editor of Metallurgical & Chemical Engineering:*

SIR:—In the issue of your magazine for March, 1914, page 157, Mr. Dyke V. Keedy has contributed a rather elaborate discussion on the concentration of complex ore from the Mary Murphy mine, based on my original article on the same subject in your January issue. It is personally gratifying to think that Mr. Keedy should have analyzed the article in such detail, but it seems to me that he set for himself a laborious task, the results of which are of little or no value, due to the fact that he draws conclusions from incomplete data and from assumptions of his own. That the data were incomplete is scarcely a legitimate criticism of the original article, for it was not an engineering report on the efficiency of the Mary Murphy mill, based on a related series of tests and investigations, but a description of operations by a visitor, with occasional figures and tabulations to show the results obtained. There is every reason to believe the general accuracy of the data given; but it is obvious that the figures were not such as would justify an attempt to make the checks and calculations submitted by Mr. Keedy. As a consequence, the fallacy of much of his contribution lies in the assumptions he has made and substituted for unstated facts.

In the first place, the weights of products (lead concentrates, zinc-iron middlings and zinc slimes) are not actual net dry weights, but the total of daily estimates made by the mill operatives on moist products, which estimates usually are well on the safe side. As a matter of fact, the actual shipments of lead concentrates credited to September operations totalled 161.62 tons, as against the daily estimates of 138 tons. The estimated tonnage should not be used in such calculations as Mr. Keedy has made, and probably he would have been spared his trouble if I had explained them more fully. Being merely estimates taken from the daily operating sheets, they might properly have been omitted. Since the weights of recovered products are not accurate, the assumed weight of tailing also is inaccurate, being estimated by difference; and the re-calculated recoveries cannot stand, being based on assumptions. Furthermore, in calculating the gold recovery Mr. Keedy assumes all amalgam as gold, thereby making even his reduced saving too high.

The method of calculating recoveries from head and tailing samples is criticized as "incorrect and misleading because of the very important fact that the large quantity of water used on the jigs and tables, and running to waste therefrom, carries unseen and frequently unnoticed an unknown quantity of mineral values." At the Mary Murphy mill the tailings from all concentrators are combined before leaving the plant, so that a fair sample of general tailing is taken. The quantity and value of suspended matter in the tailing water, escaping collection, is not as great as one would think, especially if some precaution is taken to assist settlement in the sample. Thus, on one occasion, 500 lb. of water was decanted from a settled tailing sample and evaporated to dryness. Only 2 oz. dry slime, or 0.025 per cent., was recovered, containing a trace of gold, 1.4 oz. silver per ton, 4 per cent. lead and 18.7 per cent. zinc. When one remembers the ratio of water to solids in tailing, about 15 to 1 in this case, the loss in suspended matter is seen to be inconsiderable, and a tailing sample prepared in this way forms a good basis from which, together with products, to calculate recovery.

Mr. Keedy prefers to omit from zinc and lead "recoveries" that portion of those metals contained in lead and zinc concentrates, respectively, because he says they bring no economic return and may even entail penalties. I think he understood, however, that the "recovery" figures I gave represent metallurgical saving and not economic recovery. A knowledge of the smelter contracts on the various products would be necessary to determine economic recoveries and losses, as well as possible penalties. Unquestionably loss is suffered, but it cannot be determined by assumptions. It is generally recognized that metallurgical saving and economic recovery on such an ore are not synonymous.

In regard to the electrostatic work, the failure to give weights of products in my tabulations is an omission, for they were placed at my disposal. Mr. Keedy is quite right in assuming that the assayer's figures are reliable, but he falls into a pardonable error in attempting to check up the gold in the various products from Mary Murphy ore. Weights would have been of little value in such an effort, and might have made the problem more perplexing. It is my understanding that close accounting for gold is considered one of the impossibilities at the Mary Murphy; in the mine, in the mill, and almost equally in the smelter settlements, it is strictly where you find it, and not always where it ought to be. Referring to the retreatment of electrostatic middlings, which Mr. Keedy says "resulted in a net loss," I will say that the table of figures was given for the very purpose of showing how unsatisfactory the experiment proved.

Touching on the criticism of the regrinding practice. Mr. Keedy's suggestion to by-pass the slime contained in tube mill feed is perhaps pertinent. But in objecting to too-fine grinding of the entire pulp he must not forget that the character of Mary Murphy ore is such that fine grinding is required to liberate gold, even though base minerals are slimed in the operation. It is a question of economic operation. I presume that the management of the Mary Murphy is cognizant of the value of gradual reduction in size, in concentrating such an ore. Perhaps a few months' experience at the mill would reveal to Mr. Keedy many practical difficulties which cannot be appreciated otherwise. A clearer insight to the situation will be gained by reading an article by Mr. George E. Collins, manager for the Mary Murphy company on page 243 of this issue. It furnishes many interesting details relating to the mill practice.

Denver, Colo. H. C. Parmelee.

## Pyrophoric Alloy Patent Decision

In the suit of the Treibacher Chemische Werke (Gesellschaft mit Beschränkter Haftung) vs. The Roessler & Hasslacher Chemical Company, a decision has just been rendered in the District Court of the United States, Southern District of New York. The decision which is written by Judge Hough is in favor of the complainant. The patent in question, No. 837,017, issued to Welsbach on Nov. 27, 1906, and assigned to the Treibacher Chemische Werke, is held to be valid as a pioneer patent and to be infringed.

From Judge Hough's decision we quote the following:

"The only claim involved is this: 'A pyrophoric alloy, containing cerium, alloyed with iron; substantially as and for the purposes described.'

"The 'purposes described' in the specification render plain the contest before the court.

"The patentee tells the world that all preceding investigators were wrong in supposing that the so-called 'rare-earth' metals, when pure, possessed pyrophoric capacity, i.e., the property when abraded of giving off particles self-igniting in the air.

"Admittedly these metals, and especially cerium, had long been called pyrophoric, but Welsbach deems himself the first to discover that the spark-giving quality depended on impurities whose presence had before him been unobserved, or if noted considered negligible.

"It is not pretended that this ascertainment of a natural phenomenon constitutes patentable invention.

"Since, however, the cerium ordinarily obtainable had been known to give forth sparks and abrasion, Welsbach says he sought to ascertain what kind of mixture would produce sparks in greatest abundance. Iron afforded the best results, and an alloy of cerium 70 per cent and iron 30 per cent the maximum pyrophoric effect.

"The sparks elicited are not different from those known to have been drawn from the 'rare-earth' metals as produced from Welsbach's experiments, but the flow from his alloy is said to be so copious and certain as to furnish a 'prompt and reliable' means of igniting 'combustible gases mixed with air.'

"The patentee experimented with 'certain other metals,' and mentions nickel and cobalt as possible ingredients in his alloy, but iron remains the favorite. On alleging as true the substance of the foregoing the patentee sought and obtained the wide claim above quoted.

"Defendant has imported and sold a substance manufactured by Kunheim & Company, of Berlin, said to be composed (in accordance with specification of Huber, U. S. Patent 967,775, Aug. 16, 1910), of magnesium, 15 per cent, and cerium, 85 per cent, treated with hydrogen at between 500 deg. C. and 600 deg. C., as long as any absorption of hydrogen can be detected. The magnesium-cerium compound is pyrophoric, the alleged effect of absorbing hydrogen is to increase that quality.

"The defence asserts:

"(1) Welsbach's invention to be void for lack of novelty, i.e., it covers only a 'pre-existing inherent natural property of the alloy.'

"(2) Kunheim's product is not an alloy at all, and therefore not an infringement.

"(3) The claim in suit is (in view of the prior art) too narrow to cover any alloy not containing substantially the preferred quantity of iron—or possibly nickel or cobalt.

"*First:* This defence will not stand analysis. It is true that great pyrophoric activity is, and always must have been, an inherent natural quality in an alloy of iron and cerium. It is also true that any composition of matter has inherent natural qualities—but before such qualities can be known and used—the matter composition must be produced. Nature does not produce the alloy of Welsbach, and if that alloy is novel and artificial, the compound is patentable as far as novelty is concerned.

"*Second:* The dictionary meaning of alloy is 'an artificial compound of two or more metals combined while in a state of fusion.' The important words (for this case are, *two or more metals*, and all the experts examined agree that an alloy must contain that number.

"Admittedly both magnesium and cerium are metals, and the best and sufficient evidence that defendant's product was once (at all events) an alloy, is that Huber calls it one, and defendant insists that what Huber describes—it sells.

"But it is said that the hydrogen bath has created a *cerium hydride*, which is something so different from a mere alloy of cerium and magnesium as to be a different thing, i.e., a chemical compound of admittedly uncertain properties and formula.

"On such a point as this I am as far as possible from hazarding any opinion other than one as to the weight of evidence. I see no reason to doubt the facts testified to by Drs. Fattinger and Olsen, i.e., that they made an amalgam of the alleged infringing substance, and liberated the hydrogen, thereby demonstrating that the hydrogen was physically not chemically combined with the cerium and magnesium. It seems to me that what Huber called an alloy, so remained, even though saturated (so to speak) with hydrogen.

"*Third:* The substantial question in this case is that of infringement, and that depends on the range of equivalents, permissible to the patentee . . ."

The decision then takes up the requirements of a "pioneer patent."

"Whether any given invention is a 'wholly novel device' or one of 'such novelty and importance as to mark a distinct step in the progress of the art' always and principally depends on how much men knew before they learned what the patentee taught.

"Before the disclosures of Welsbach it is, I think, shown that men knew nothing of the certain and reliable preparation or manufacture of a pyrophoric alloy. They thought they knew that cerium was pyrophoric, whereas they had merely observed sparks given out by an impure metal, without connecting the impurities and sparks, as cause and effect.

"Before Welsbach there was and could be no *art*, in pyrophoric substances, because the basis of all art, certain knowledge, was lacking. This patentee taught how certainly and knowingly to produce that which had been observed indeed, but not understood. Such invention is indeed pioneer.

"The argument against the above conclusions rests upon several patents, and the disclosures of numerous scientific publications.

"One good reference or publication is worth more than a volume of poor ones, and I select the German patents to Escales, the article of Hillebrandt and Norton and Moissan's article in *Der Elektrische Ofen* as covering the whole defence."

These are briefly reviewed by the Court and it is said that "Moissan is much nearer the point in his opinion (*meiner Ansicht*) that it would be better to use (for fire-making apparatus) 'an alloy of iron with uranium,' but he never did it, and he did not tell anyone just what to do.

"Prophecy is often greater than invention, but it is not patentable.

"Believing then that this is a pioneer invention, can the doctrine of equivalents be invoked to read the claim in suit, an *alloy* of cerium with any other metal, provided that such alloy be pyrophoric?

"On this head the first inquiry is whether the patentee has tied his own hands, by limiting his claims. Groth vs. International &c. Co., 61 Fed. Rep., 284.

"Such is asserted to be the case here, for iron only is mentioned in the claim; but the inventor shows that the cerium is to be alloyed with iron or its equivalent (line 67), so that the final question is what are the equivalents of iron in a pioneer patent, when the specification shows that the invention is far wider than the use of iron only.

"As has been often said, where a valuable invention has been made it is the duty of the Court to uphold that which was really invented.

"What Welsbach invented was a metallic alloy having certain desirable qualities—he knew and said that iron was not the only (though it was the most desirable) component with cerium.

"If a metal other than iron be used, does the resultant embody Welsbach's invention? This is the root query.

"The question is one of fact, not law, and the innumerable cases on equivalents are merely statements of how the minds of sundry judges have worked when sitting as jurymen.

"To me it is obvious that the usefulness of an alloy, i.e., a fusion of metals, was Welsbach's plainly disclosed invention—without knowledge thereof Huber would not have known that it was useful to make an alloy of magnesium and cerium, therefore, he used and uses Welsbach's invention and is an infringer."

---

## The Brown Cyanide Patent Decision on Appeal

In our issue of October, 1913, page 541, reference was made to the Brown cyanide process patent decision, by which in the United States District Court for the District of Delaware (Judge Edward G. Bradford) the Tonopah Mining Company was found to have infringed a patent of Alden H. Brown. This decision has now been reversed by the United States Circuit Court of Appeals for the Third District (Judges Gray, Buffington and McPherson) and the case remanded with instructions to dismiss the bill for non-infringement.

Brown's patent has special reference to the sequence of several steps by which the metals are recovered by cyanidation and concentration. Customarily an ore requiring both concentration and cyanidation is subjected to the treatment in the order mentioned. Brown's patent covers the reverse method, viz., cyanidation followed by concentration. His second or broad claim reads: "A process of treating sulphide ore consisting first in subjecting the raw or unroasted ore to the action of a cyanide solution whereby the finer metallic values are dissolved, and second, subjecting the ore or tailings to concentration whereby the coarser values are recovered."

In the decision of the Court of Appeals, written by Judge Buffington, Brown's invention is analyzed at some length.

"It will be noted that no new principle of operation, either in cyaniding or concentrating themselves was disclosed in this patent. It was at most simply a more effective treatment and it will thus be seen that transposition of concentration from initial to final stage, and of cyaniding from final to initial stage is the substantial disclosure of this device. Assuming, for present purposes, that this change was original with Brown, and that it involved invention it must be conceded the field of invention was narrow, and Brown's claim should not by construction be enlarged to include within infringing fences processes which were not within the field of his inventive disclosure. Not without entering into details it suffices to say that the second claim embodies the two elements of, first, cyaniding, viz., 'subjecting the raw or unroasted ore to the action of a cyanide solution whereby the finer metallic values are dissolved,' and, second, concentrating, viz., 'subjecting the ore or tailings to concentration, whereby the coarser values are recovered.' This claim is perfectly clear. A reading of the patent shows precisely what the patentee disclosed, and the claim precisely claims that disclosure. There is no ambiguity in either disclosure or claim. They are self-sufficient and self-explanatory.

"This two-staged process, first, cyaniding; next, concentrating, being the only disclosure of Brown and the claims embodying these two separate, individual, completed stages or steps, it follows that any process which makes concentration an intermediate and completed step, one that precedes final and effective cyaniding, is a process different from the one Brown disclosed and claimed. Measuring the defendant's process by these standards, it follows that infringement is not shown, for, without entering into a detailed description of its plant, it suffices to say that a study of its workings has brought us to this conclusion. The defendants, in common with Brown, it may be conceded, are using the cyanide solution in the earlier stage of their process, and to that extent we may say initially utilize the general chemical treatment incident to cyaniding, preparatory to concentrating. But beyond this the resemblance ceases, for by defendant's process concentration—effective, finished and final—is the initial and intermediate step in their process. At such intermediate step the fruits of concentration are withdrawn from the process, and this first completed step of the process, the one 'whereby the coarser values are removed,' is, as we have seen, the second step of Brown's process.

"After the defendant's concentration is finished, the by-product goes forward to be subsequently treated by a protracted process of cyaniding. This is at variance with Brown's process in three respects, first, cyaniding follows concentrating; second, it is a system condemned by Brown and one he sought to avoid in that where 'concentration . . . is used preliminary to the cyanide process it will be necessary to have a very extensive system of settling tanks in order to recover these suspended values and hold them in the mill so that they may be subjected to further treatment'; third, the defendant's process which physically withdraws from the operation of the process the products of concentration in advance of withdrawing those of cyaniding, makes the process one avoided by Brown, viz.: 'It is a well-known fact that the cyanide process recovers only the fine values and in the treatment that I have devised these fine values are recovered by the cyanide process in the beginning, leaving only the coarser values, which are readily recoverable by concentrating, the latter being specially adapted for saving this class of values.'

"It is apparent, therefore, that the defendant's device, which the proofs show has been of great practical worth, owes its worth to the fact that it is built and operated in express disregard to the instructions of Brown's patent. Without passing on the question of the validity of that patent it suffices to hold defendants do not infringe."

BUST OF MORRIS LOEB

## Presentation of the Bronze Bust of the Late Morris Loeb to the Chemists Club

At a meeting of the New York Section of the American Chemical Society, held in the Chemists' Building, New York City, on March 6, 1914, a bronze bust of the late Morris Loeb was dedicated and presented to the Chemists Club.

Dr. L. H. Baekeland, in his speech of presentation, sketched the ideals of Morris Loeb and his work for chemistry in America and the Chemists' Club. Dr. Baekeland concluded as follows:

"After his untimely death, which left so many in sorrow, it was found that by his will Morris Loeb had planned the realization of the ideals he had preached.

"To his university, Harvard, he left a large sum of money for chemical research; to the Chemists' Building, he gave all his shares; to the American Chemical Society, he left a fund for the creation of a chemical museum along the lines conceived and clearly described by him.

"None of us, who have known Morris Loeb, who have lived, worked, or spoken with him, need a bust nor a portrait to remind us of the man or his work. But as we grow older and death keeps thinning out our ranks, younger generations of chemists will use these halls. Our duties, our responsibilities will become their duties, their responsibilities.

"I have no doubt that their aims for good will be of the highest; that they will better realize than the present generation that to be a chemist is to be an apostle of progress and civilization, of justice and truth.

"But the chemists of the coming generation will not have known Morris Loeb, and we must remind them of what one of our generation dreamt, planned and did for them.

"This is the reason why some friends of Dr. Loeb obtained a bronze bust from Mr. Karl Bitter, an artist whose reputation is no longer to be made.

"It is their desire that this bust should adorn the halls of the Chemists Club.

"Dr. McKenna, upon you, as president of the Chemists Club, devolves the responsibility of placing this bust where it will best serve its purpose."

---

**The preliminary report on mineral production in Canada in 1913**, by the Dept. of Mines, shows a total value of production in the year just closed of $144,031,047. Although estimates have been made in some cases where complete returns were not available, it is probable that the final record will be a revision upward. The total value of the production in 1912 was $135,048,296, compared with which the 1913 output shows an increase of $8,982,751, or 6.65 per cent. In view of the large increase over all previous years made in mineral production in 1912 and the general trade depression and industrial restriction experienced during the latter part of 1913 the industry would appear to have made in the aggregate very satisfactory progress. The average production per capita in 1913 was $18.57, as against $18.27 in 1912 and $14.93 in 1910.

## Program of New York Meeting of American Electrochemical Society

The twenty-fifth general meeting of the American Electrochemical Society will be held in New York City on Thursday, Friday, and Saturday, April 16 to 18.

The headquarters will be at the Chemists' Club, 52 East Forty-first Street. There will be technical sessions on the morning and afternoon of Thursday in Rumford Hall in the Chemists' Building, 50 East Forty-first Street, and on Saturday morning and afternoon in Earl Hall, Columbia University. There will be a smoker on the evening of Thursday in Rumford Hall, Chemists' Building, and a dinner-dance on Saturday evening also in the Chemists' Building.

On Friday there will be an all-day excursion by steamboat around New York Harbor and Staten Island combined with visits to the plants of the American Smelting & Refining Company, the United Lead Company, and the Waclark Wire Company. The arrengements for the meeting are in the hands of the New York Section of the American Electrochemical Society, and the smoker on Thursday night and the steamer party on Friday are complimentary affairs tendered by the New York Section.

The program of the technical sessions is as follows:

**Thursday, April 16, 9 a. m.,** Rumford Hall, Chemists' Building: Annual business meeting, followed by Symposium on Power Problems in Electrochemistry:

C. P. Steinmetz, Characteristics of Electrical Energy as Affecting Chemical Industries.

P. Sothman, Efficiency of Power Transmission Versus Utilization in Local Electrochemical Industries.

F. A. J. FitzGerald, Economics of Electric Furnace Operation.

W. S. Horry, Power Supply to Electric Furnaces.

Lawrence Addicks, The Power Problem in the Electrolytic Deposition of Metals.

H. E. Longwell, The Power Problem in the Electrolytic Deposition of Metals.

F. D. Newbury, Sources of Direct Current for Electrochemical Processes.

General discussion.

**Thursday, 2 p. m.,** Rumford Hall, Chemists' Building:

Wilder D. Bancroft, Electrolytic Flames (An Experimental Lecture).

C. A. Hansen, Electric Steel Castings.

Eugene B. Clark, Electric Furnaces for Steel Making.

G. C. Stone, Improvements in the Metallurgy of Zinc.

W. R. Ingalls, Electric Zinc Smelting.

W. P. Lass, Advantage of Southeastern Alaska for Hydro-electrochemical Industries.

**Thursday, 8 p. m.,** Rumford Hall, Chemists' Building:

E. F. Roeber, Some Economic and Aesthetic Aspects of Electrochemistry (Presidential Address).

**Thursday, 8.45 p. m.,** Smoker.

**Saturday, 9 a. m.,** Earl Hall, Columbia University:

E. A. C. Smith, Progress in Leaching and Electrolytic Treatment of Copper Ores in South America (A Lecture).

R. R. Goodrich, Hydro-electrometallurgy of Copper.

Rudolph Gahl, Leaching of Copper Tailings.

Ralph W. Deacon, Metal Inventory in an Electrolytic Copper Refinery.

Joseph W. Richards, Electrolytic Zinc.

O. P. Watts and A. C. Shape, Addition Agents in the Deposition of Zinc from a Solution of Zinc Sulphate.

Frank C. Mathers and O. Ralph Overman, The Effect of Addition Substances in Lead Plating Baths.

Frank C. Mathers and Hugh M. Marble, Electrodeposition of Cadmium.

C. W. Bennett, H. C. Kenny and R. P. Dugliss, Electrodeposition of Nickel.

C. W. Bennett and A. W. Davison, Electrolytic Deposition of Brass on a Rotating Cathode.

Gustave E. F. Lundell, A New Method for the Determination of Free Cyanide in Electroplating Solutions.

**Saturday, 2 p. m.,** Earl Hall, Columbia University:

E. F. Northrup, Electric Conduction at High Temperatures and Methods of Measurement (An Experimental Lecture).

F. A. J. FitzGerald, Laboratory Notes on Some Electrical Properties of Silver Sulphide (with experiments).

Claude N. Hitchcock, Polarization Single Potentials.

Reinhard Beutner, New Cell Arrangements for Direct Determination of the Free Energy.

R. Stuart Owens, Experiments on White Lead.

Oliver W. Storey, A Microscopic Study of Electrolytic Iron.

O. P. Watts and M. H. Li, The Effect of Addition Agents in the Electrodeposition of Iron.

O. L. Kowalke, Base-Metal Thermocouples and Their Microstructure.

**Saturday, 7 p. m.,** Subscription Dinner, followed by Dancing, at the Chemists' Club.

The arrangements of the meeting are in the hands of the New York Section, of which Mr. Lawrence Addicks is the chairman and Mr. H. B. Coho (United Lead Company, 111 Broadway, New York City) is the secretary.

## The Western Metallurgical Field

### Flotation and Cyaniding

Flotation processes have been used mainly with the object of producing from ores a marketable concentrate for subsequent smelting. Low-grade zinc and copper ores are thus treated quite extensively. Another possible field for flotation, which has not received very much attention, is the concentration of gold ores, with the idea of cyaniding the concentrates thus produced. Some preliminary work along this line has been done by Mr. Justin H. Haynes, and the proposal seems worthy of consideration in cases to which it is applicable. The type of ore most amenable to such a process would be a simple pyrite in silicious gangue, the gold and silver being contained wholly or mainly in the pyrite and not distributed through the gangue. From this ideal condition we might extend the process to ores containing some galena also; but the principal point to be observed would be the association of the precious metals with the sulphide constituent, so that on floating the concentrate the tailing might be discarded as worthless.

The rejection of sand tailing characterizes some present operations in which table concentration plays a part. Thus at Cripple Creek, the Portland company first concentrates the ore, removing sulpho-tellurides, and then classifies the remaining pulp into sand and slime, discarding the former. A similar procedure was in effect at Idaho Springs when the Hudson mill was running. Of course, there are districts in which the nature of the ore will not permit the rejection of the sand.

Flotation, however, might offer some advantages even in the cases cited, for it would recover in one concentrate the slime mineral as well as the coarse which is now caught on tables, and thus render the slimy as well as the coarse gangue without value. We would then have for treatment by cyanidation only the concentrate, which would be but a fractional part of the crude ore. The cyanidation of concentrates is practiced in numerous places. Where this is possible, flotation would be an excellent means of first getting *all* the mineral in a concentrate of high grade. The cost of cyaniding and the metallurgical losses sustained in that process would then be greatly reduced when calculated per ton of crude ore, and certain refinements could be introduced that would be prohibitive if applied to original ore. The object of flotation would not be the production of a marketable concentrate, containing as little gangue and as much mineral as possible, but primarily to get all the mineral, even though it was accompanied by more gangue than would be permissible if the concentrate were to be smelted. The cost of the cyaniding plant would be greatly reduced, as also would that of the concentrating department, and a mill based on such a process might come within the means of companies owning small mines.

### Smelters and Farmers

Rumor has been current to the effect that the farmers of the Tooele district in Utah expect to make trouble for the International Smelting & Refining Co., which has a large copper and lead smelter there. It is unlikely that such will be the case, or at least it seems so in view of the elaborate precautions taken by the company before the smelter was located there and before operations were commenced. At that time the company had experts in the field making observations on the condition of the flora of the region, with special reference to agricultural and horticultural crops. It is understood that the company at that time took options on much of the land, with the intention of buying them if the farmers preferred to sell. Under these conditions it seems doubtful if the farmers could present a good case, and it is likely that many of them will care less about litigation when they find that the company stands ready to buy their land.

The situation in California is not so favorable to the smelters, and some interesting developments may occur there this summer. Incidentally it may be stated that experimental work with the Hall process of distilling and recovering sulphur from ores is proceeding, and that the early results are encouraging.

### Chlorination Processes in Utah

Mention has been made previously in this column concerning the adoption of a process of chlorination at two mills in Utah: one at Park City, where the Mines Operating Co. is treating ore from the old Ontario; and the other at Silver City, where Jesse Knight is completing a new mill. Within the past month it has been announced that a third mill, also at Park City, is to adopt a similar process. The dry concentration mill formerly operated there by the Grasselli Chemical Co., treating zinc middlings, has been purchased by Salt Lake parties, and will be remodeled into a custom mill using a process based on chloridizing-roasting and leaching. Ore from the American Flag mine, among others, will be treated. The owners of this property have been making metallurgical investigations for some time, seeking the best method of recovering gold, silver, copper, lead and zinc, all of which exist in the ore in small quantities. We are informed that concentration has yielded poor results. A combination of concentration and cyaniding has done much better, but the process which has been adopted is said to have yielded by far the best results, with a probability of making a good recovery of all the valuable metals. The anticipated cost of treatment is given as $3.50 per ton, and the recovery as over 90 per cent of all the metals.

### Oil Flotation at Butte & Superior

According to a report filed by the Butte & Superior Copper Co. in the federal court, in accordance with the court's order pending settlement of a suit brought by the Minerals Separation, Ltd., the company treated in January by flotation 29,188.9 tons of ore, yielding 7062.6 tons of concentrates. The cost of this part of mill operations is given as $4.225 per ton, and the value of concentrate as $23.45 per ton. About 88 per cent of the ore handled in the mill was treated by flotation. The following tabulation shows the results of flotation on that part of the tonnage thus treated.

| | Heads | Concentrates | Tailings |
|---|---|---|---|
| Zinc, per cent | 13.91 | 50.71 | 2.06 |
| Lead, per cent | 0.77 | 4.43 | 0.15 |
| Copper, per cent | 0.19 | 0.45 | 0.04 |
| Iron, per cent | 2.73 | 1.39 | 0.94 |
| Manganese, per cent | 1.44 | 2.72 | 0.85 |
| Insoluble, per cent | 68.87 | 10.82 | 91.50 |
| Silver, oz. per ton | 7.73 | 26.55 | 1.62 |
| Gold, oz. per ton | 0.02 | 0.05 | 0.004 |

### Company Reports

*The Arizona Copper Company, Ltd.*, has made public a report of its operations for the year ended September 30, 1913. The year's production of copper was 34,230,000 lb., being less by 3,920,000 lb. than for the preceding year. This decrease is partly accounted for by a lower grade of ore and by delay in getting the new smelting works in operation up to capacity. The ore mined from the company's properties yielded 38.76 lb. copper per ton, a decrease of 2.39 lb. per ton as compared with last year. During the year 780,887 dry tons of ore was concentrated, 68.7 per cent of the quantity being handled at No. 6 concentrator and the balance at the Clifton concentrator. The average ratio of concentration was 7.26 to 1. The work at No. 6 has been handicapped by reconstruction which has been under way. Hardinge mills have been substituted for Huntington mills. The works for treating oxidized ore by concentration handled 106,596 dry tons of ore, and 85,071 tons of tailings from this concentrator was leached. The copper recovered from oxidized ores amounted to 9.27 per cent of the total production. In the smelting department a total of 151,265 tons of ore and concentrates was smelted. The average yield of copper from material smelted was 11.31 per cent. The old smelting plant was closed on December 31, 1913, the new plant having been started in August.

From the report of the *Mount Morgan Gold Mining Co., Ltd.*, Mount Morgan, Queensland, we excerpt the following items on operation as given by Mr. B. Magnus, general manager. The following table gives statistics from the reduction works for the six months ending November 30, 1913:

| | Tons | Copper obtained, tons | Copper, per cent | Gold, ozs. obtained | Gold, dwts per ton |
|---|---|---|---|---|---|
| Copper ore | 123,247.00 | 3,852.49 | 3.125 | 52,484.58 | 8.516 |
| Many Peaks ore | 25,632.00 | 336.63 | 1.313 | 198.26 | .154 |
| Purchased ores | 45.77 | 7.75 | 16.932 | 60.80 | 26.567 |
| Miscellaneous products | 3,091.19 | 157.19 | 5.085 | 2,248.86 | 14.550 |
| | 152,015.96 | 4,354.06 | 2.864 | 54,992.50 | 7.235 |

The copper ore smelted assayed about 55.6 per cent silica, which is 3 per cent higher than for any previous period. This has entailed extra expense for fluxing material, and has added to cost of operation, as it costs approximately 6½d. (13c) per unit to flux silica. This points to the necessity of getting the concentrator in operation as soon as possible. When the latter is running, ore containing over 52 per cent silica will not be smelted direct unless it is high in gold content. Experimental work in concentrating has proceeded, and a representative of Minerals Separation has been on the ground to check up the work. The recovery is better than estimated, and the cost is less. Serious delay has been experienced in delivery of steel for the new smelter building, and has materially deferred the blowing in of the new plant. A Dwight-Lloyd sintering plant will be installed to handle flue dust.

## "Skin Effect" in Carbon Electrodes

BY A. T. HINCKLEY

At the spring meeting of the American Electrochemical Society in 1912, Mr. Turnbull's paper on Furnace Electrodes gave rise to some discussion as to the magnitude of the "skin effect" in large electrodes. No one apparently had any figures on the subject, and the question was settled by the opinion of Mr. Hansen that the effect should not be large owing to the relatively high resistivity of carbon.

Since that time the question has come up several times whether or not carbons in the form of hollow cylinders would give longer life in electric furnace work, as the "skin effect" would be less in such carbons than in the solid cylindrical ones. As far as we know there have been no figures published concerning this up to the present time.

In the *Journal* of the Franklin Institute for February, 1914, Mr. Carson, working with Dr. Northrup at Princeton University, has given a mathematical treatment of the "Skin Effect and Alternating-Current Resistance" phenomena. From these data we have calculated the magnitude of this effect in 24-in. round carbon electrodes.

$R_{ac}$ = resistance per unit length for alternating currents.

$R_{dc}$ = resistance per unit length for direct currents.

The magnitude of the ratio $\frac{R_{ac}}{R_{dc}}$ is desired.

$$\frac{R_{ac}}{R_{dc}} = \frac{1 + c_1\left(\frac{\mu f a^2}{\rho}\right)^2 + c_2\left(\frac{\mu f a^2}{\rho}\right)^4 + \cdots}{1 + \frac{c_1}{2}\left(\frac{\mu f a^2}{\rho}\right)^2 + \frac{c_2}{3}\left(\frac{\mu f a^2}{\rho}\right)^4 + \cdots}$$

$c_1 = 6.49 \times 10^{-5}$

$c_2 = 3.55 \times 10^{-10}$

$\mu$ = permeability

$f$ = frequency in cycles per second

$a$ = radius of conductor in cm.

$\rho$ = specific resistance per cm cube, in microhms.

For a 24-in. round carbon electrode used on a twenty-five-cycle circuit,

$\mu = 1$ (practically)

$f = 25$

$a = 30.48$

$$\rho = \frac{0.0020 \times 6.45 \times 10^6}{2.54} = 5100$$

$$\frac{\mu f a^2}{\rho} = \frac{1 \times 25 \times 30.48^2}{5100} = 4.54$$

$$\frac{R_{ac}}{R_{dc}} = \frac{1 + 6.49 \times 10^{-5}\,(4.54)^2 + \ .\ \ .}{1 + 3.24 \times 10^{-5}\,(4.54)^2 + \ .\ \ .}$$

$$= \frac{1 + 133 \times 10^{-5}}{1 + 67 \times 10^{-5}}$$

$$= \frac{1.00133}{1.00067}$$

That is, the $R_{ac}$ of a carbon electrode 24 in. diameter is only 0.066 per cent higher than the $R_{dc}$. On this account there would be practically no tendency for the alternating current to concentrate at the surface of the carbon and the use of a hollow cylindrical carbon in place of a solid one becomes unnecessary.

Research Laboratory, National Carbon Co.,
Niagara Falls, N. Y.

**The annual trip of inspection** of the senior class of the Colorado School of Mines will start from Denver on April 20 and last four weeks. The principal mining and metallurgical centers of Colorado, Utah and Montana will be visited.

## The Electric Iron Ore Smelting at Hardanger in Norway—II.

BY JOH. HÄRDÉN

In an article* in the February issue, page 82, I gave an account of the first part of Mr. G. Oedqvist's paper, read before the Polytechnic Society of Christiania.

In the following, the second part of Mr. Oedqvist's paper, published in *Teknisk Tidskrift*, Jan. 28, 1914, will be reviewed.

### The Quality of the Pig Iron

The results at Hardanger have shown that it was quite possible to produce a good quality of pig iron, free from obnoxious impurities, although coke was used as reducing agent. But the uniformity of the product was far from satisfactory.

The principal reason of the considerable variations in the product is to be found in the undesirable fluctuations of the power consumed by the furnace, with which the author deals further on, and which caused great variation of the temperature in the smelting zone. The real reason of the poor uniformity of the product is therefore, according to Mr. Oedqvist, to be found in the furnace itself.

These variations will be even more prominent when coke is used solely, instead of charcoal .

However, such great variations as those at Hardanger need not always occur, as is evident from the results during the last period when a considerable improvement was obtained. It is clear that the faulty electrical arrangement has had a great influence in this respect as well as with respect to the large percentage of scrap produced.

### Stoppages and Interruptions

Table VI shows the stoppages at Hardanger, compared with Uddeholm and Strömsnäs.

TABLE VI

| | Stoppages in Per Cent | Interruptions per 24 Hours in Average, Hours |
|---|---|---|
| | About | About |
| Hardanger, Period I | 20.8 | 5 |
| Hardanger, Period II | 8.5 | 2 |
| Hardanger, Period III | 3.0 | ¾ |
| Hardanger, Period IV | 14.0 | 3 1-3 |
| Uddeholm, Furnace No. 1, March 15 to December 31, 1912. | 4.0 | 1 |
| Uddeholm, Furnace No. 2, August 1 to December 31, 1912 | 4.2 | 1 |
| Stromsnas, October 1 to December 31, 1912 | 2.2 | ¼ |

Standstills at Trollhättan during the period from Aug. 4, 1911, to Sept. 30, 1912, amounted to about 5.5 per cent. One of these stoppages not due to the working of the furnace or directly caused thereby amounted to 4.7 per cent, while only 0.8 per cent interruptions were directly due to the furnace, corresponding to about ten minutes for each day of twenty-four hours.

The individual causes for the stoppages at Hardanger are not stated in the reports issued, but it appears most likely that the numerous interruptions were mostly caused by breakage of electrodes. That these interruptions had a decisive effect on the uniformity of the product and the general results is quite certain and need not be further explained.

---

*In this article there is an error on page 83. Line 13 and the following lines of the first column should read: "Hence it seems very likely that a regulation of from 45 to 75 or 80 volts would have been sufficient, with a booster for raising the voltage to say 90 or 95 volts, to be resorted to in cases of emergency, to break through the charge if this furnace got cool after a tapping."

### The Load Factor

Table VII shows the electrical load of the furnace at Hardanger, taken as an average for the two best periods.

TABLE VII

| The Hardanger Furnace for the Period | Normal Average Load in K.W. | Average Minimum Load | | Average Maximum Load | |
|---|---|---|---|---|---|
| | | In K.W. | Decrease in Per Cent of Average Normal Load | In K.W. | Increase in Per Cent of Average Normal Load |
| | | | About | | About |
| September 7 to September 21, 1912. | 1736 | 804 | 54 | 2207 | 27 |
| March 6 to March 29, 1913 ... | 2004 | 756 | 62 | 2857 | 42.5 |

The table shows that the variations in power consumed by the furnace were very great, and that an overload capacity of at least 42.5 per cent above the average normal load was required.

The author does not state the duration of these variations in detail, although especially the period of the overload is of importance in its bearing upon the size of the power plant.

The paper concludes: These irregularities, which were prevailing at the furnace and which were caused by the variations in resistance to which the descending mass of charge was subjected, prevented largely an economic utilization of the available power supply.

The same disadvantages are also well known from some other furnaces in which electrodes are used. The experiences at Trollhättan show that about 200 kw above the normal load must be provided for.

Practically all furnace plants require such overload facilities, at least to a certain extent, since some variations are almost inevitable at times.

At Hardanger, where coke was used only, the above figure of 200 kw was not sufficient, since at least 850 kw over the normal load was occasionally required, and at times even as much as 1000 kw.

This seems to indicate that the use of coke is a direct reason for these variations, especially when the volume of the charge is large in comparison with the volume of the coke.

The paper quotes an extract in this connection from statements made at Trollhättan, from "The Jernkontorets Annaler," 1912, page 319:

"Now it is to be noted that the resistance of the charge in the smelting zone varies for one and the same kind of charge, according to the depth of the iron bath, and in addition, considerably for various kinds of charges. A rich charge, with a small addition of lime only, will cause a rise of the current, and this increase in current consumption will be greater as the 'charge setting' is less, or, in other words, the greater the proportion is between the volumes of the charcoal and the ore charges. A less rich charge again (which also frequently calls for a higher percentage of lime) is acting in the opposite direction, so that a higher voltage is required to obtain the same current density as in the first case."

"We have had sufficient experience in this respect and if the last-mentioned conditions were prevalent, the voltage of 90 volts, which was our maximum voltage obtainable without reconnecting the transformers, was even not quite sufficient during the first hour after tapping, so that the power decreased several hundred kilowatts."

At Hardanger, where no booster was provided and the maximum voltage was only 78 instead of 90 volts as at Trollhättan, the discrepancies must have been even greater, since coke was used.

(This seems not quite evident to our mind, since a coke charge as a rule has a lower resistance than a charcoal charge, although the volume of the coke is less than that of the latter; an increase of the voltage would have heated up the current path in a comparatively short time, to permit a subsequent decrease to the normal.)

The paper continues: As the low voltage range could not be altered without considerable cost, it seems that the best remedy would have been to work with a richer charge. Instead of this, however, the works at Hardanger chose the opposite way. They abandoned the richer charges and commenced to use Persberg ore with 53 per cent Fe and a charge, giving only about 42 per cent yield.

The result was that the variations in load became greater during this period, compared with the foregoing one, when the charge was richer.

### Production

The output of pig iron per year is, of course, of the greatest importance, as far as the economic result generally goes. Table VIII gives a fair idea of the output compared with the results from Trollhättan, Uddeholm and Strömsnäs.

TABLE VIII

| Plant | Per Cent Pig Iron of Goods | Production | | Average Load in Kilowatts | H.P. Available for the Furnace | Tons Pig Iron | | | Yearly Production in Tons | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Tons per 24 Hours | Tons per 24 Hours, Actual Work | | | Calculated H.P. Year | Per Actual H.P. Year | | Calculated | Real[1] | |
| | | | | | | | At 365 Work Days | At 335 Work Days | | Per 365 Work Days | Per 335 Work Days |
| Hardanger, Period I ... | 38.1 | 5.95 | 7.51 | 1665 | 3500 | 1.28 | 0.62 | 0.57 | 2743 | 2172 | 1993 |
| Hardanger, Period II | 50.7 | 9.6 | 10.55 | 1734 | 3500 | 1.58 | 1.0 | 0.92 | 3850 | 3505 | 3217 |
| Hardanger, Period III | 56.4 | 12.11 | 12.48 | 1703 | 3500 | 2.01 | 1.26 | 1.16 | 4555 | 4419 | 4056 |
| Hardanger, Period IV | 41.65 | 10.48 | 12.16 | 1942 | 3500 | 1.87 | 1.09 | 1.0 | 4447 | 3827 | 3512 |
| Trollhattan, Aug. 4, 1911 to March 6, 1912 | 56.84 | 14.92 | 15.98 | 1482 | 2850 | 2.9 | 1.56 | 1.43 | 5834 | 5445 | 4997 |
| Trollhattan, Aug. 12, 1911, to September 30, 1912 | 63.77 | 19.53 | 19.72 | 1653 | 2850 | 3.2 | 2.5 | 2.3 | 7213 | 7128 | 6542 |
| Uddeholm, No. 1 | 53.5 | 16.82 | 17.52 | 1940 | 3235 | 2.45 | 1.9 | 1.74 | 6395 | 6141 | 5636 |
| Uddeholm, No. 2 | 52.9 | 19.31 | 20.15 | 1998 | 3235 | 2.7 | 2.18 | 2.0 | 7355 | 7046 | 6467 |
| Stromsnas .. | 61.78 | 20.72 | 21.2 | 1833 | 2850 | 3.1 | 2.65 | 2.45 | 7736 | 7561 | 6940 |

The column "Tons of pig iron per calculated hp-year" refers to the amount of iron, which would have resulted per hp-year, if the power is taken only as per average load, without any stoppages, for a period of fully twelve months. Tons of iron per actual or real hp-year again means the actual quantity produced in proportion to the amount of power provided for the furnace with a smelting time of 365 and 335 days per year, or 12, respectively eleven months.

The "calculated" yearly production refers to the output which would result during twelve months, without interruptions, and the "real" production indicates the output resulting when stoppages are considered and the smelting period is both twelve and eleven months.

The total production per year at Hardanger was, as the table shows, considerably less than from the other plants, in spite of the fact that the Hardanger plant had the largest electrical equipment.

The causes of such a low production figure is, according to Mr. Oedqvist, that only a small proportion of the power available could be utilized in the furnace, as compared with the other plants, and that this was to a great extent the direct result of the attempt to use coke as reducing agent. Further, that the charge as a general rule had too low percentage of iron. The insufficient electrical arrangements also largely influenced the results during the three first periods.

The above statement by the author of the paper seem to utterly condemn the use of coke for this industry. While this may be so for the plant in question, it would be, to our mind, premature to claim this as a general rule. Trials have shown that coke can be used with good results, if the conditions otherwise are suited for that material, though charcoal would be the ideal reducer. But as already said, this material is gradually rising in price to such an extent that its use is very limited; hence it seems inevitable that serious steps are called for, to enable the use of the more common coke, even if the power-consumption per ton of iron should be thereby increased.

### The Electric Efficiency

The electric energy required for this metallurgical process, as compared with the amount of power provided for the plant, is called "the real electric efficiency" by the author of the paper.

This does not include such power as is required for auxiliary machinery necessary, etc., but such losses as occur in the transformers, the power line, cooling of contacts (holders, etc.), radiation losses, variation in working, etc., are included.

Some of the data, which have a bearing upon this, are lacking, wherefore the following figures are more or less approximate, but as they are of general interest they are reproduced in the paper.

TABLE IX

| Plant | The "Real" Electric Efficiency, Per Cent |
|---|---|
| | About |
| Hardanger, Period I | 23 |
| Hardanger, Period II | 30 |
| Hardanger, Period III | 30 |
| Hardanger, Period IV | 41 |
| Uddeholm, Furnace 2, August 4 to December 31, 1912 | 57 |
| Strömsnäs, October 1 to December 31, 1912. | 60 |

The above figures should not be regarded as an absolute statement of the efficiency of the respective furnaces, but show the working efficiency only under the specific conditions prevailing during the periods mentioned.

### Cost of Electric Energy Per Ton of Pig Iron

The comparative costs of electric power per ton of pig iron produced, both at Hardanger, Uddeholm and Strömsnäs, are shown in Table X.

TABLE X

| | COST OF ELECTRIC POWER | |
|---|---|---|
| | Per Calculated Ton of Pig Iron, Shillings | Per Actually Produced Ton of Iron, Shillings |
| Hardanger, Period I | 42.53 | 58.52 |
| Hardanger, Period II | 30.30 | 36.265 |
| Hardanger, Period III | 25.61 | 28.77 |
| Hardanger, Period IV | 26.23 | 33.21 |
| Uddeholm, Furnace I | 16.86 | 19.13 |
| Uddeholm, Furnace II | 14.66 | 16.66 |
| Strömsnäs | 12.28 | 13.69 |

The figures for "per calculated ton of iron" refer to the cost per ton as calculated for an output which would have resulted if no stoppages had taken place. The other column, marked "per actually produced tons of iron," includes all stoppages. The table is drawn up under the assumption that the furnaces could be working fully eleven months per year.

The initial cost of power is taken to be equal for all three plants and assumes to be 33.33 shillings per hp-year.

Luton, England.

## Some Notes on Stamp-Mills and Milling

BY WM. H. STORMS

There has already been published a large amount of literature on the stamp-mill, so the subject is by no means a new one, but in the following I wish to call attention to a number of matters connected with stamp-mills and milling that usually receive little consideration from those who write on the subject, probably because these matters, in themselves, are so simple that they seem to deserve no particular mention.

I believe, however, that there are many who will find something herein that will be useful to him if he is called upon to run a stamp-mill.

### Something About Mortar-Blocks

There has come to exist a very general belief that the mortar of a quartz-mill must have solid bedrock as a base for the mortar-block, and that without it disaster is sure soon to follow. It is desirable to have a bedrock foundation if it can be easily obtained, but it is by no means imperative that the mortar-block, whether of wood or of concrete, rest upon bedrock.

If the block be of wood and a bedrock foundation is readily accessible, it is good practice to lay a foundation of concrete at least 14 in. thick (18 in. is better), in the bottom of the pit on the bedrock, for the reason that the bedrock surface exposed may be of unequal hardness, and should this prove to be the case, the mortar-block is likely to discover the fact later and a movement begun in the wooden structure which will, in time, cause the mortar to have a rocking motion, which is about as undesirable a thing as could happen.

Such a motion is most undesirable for various reasons. It causes the vibrations of the mortar to be unequally distributed; anchor bolts are likely to break, and other damage result, which might have been avoided had a concrete bed been first properly laid. If a bedrock base is unobtainable at reasonable depth, 16 to 18 ft., at most, then the entire mortar block should be made of concrete, giving the sides and ends such a slope angle as will insure a broad base.

Cut the bottom of the pit as nearly level as possible and then build the form within which the concrete is to be placed.

The concrete should be made of clean rock, sharp, clean sand and the best quality of cement obtainable, for the block is to be subjected to what is, perhaps, the hardest usage that concrete foundations are ever required to withstand. A good concrete mixture consists of four parts of clean firm rock, broken to pass a 2½-in. ring; two parts of sand and one part of dry cement. The concrete should be dumped into the form as fast as mixed and rammed until water stands at the surface. When the concrete block is approaching the desired height it will be well to make the last 5 or 6 in. of a somewhat richer mixture, as this is less likely to crack.

If the mortar-block is to be of wood, have it at least 12 ft. long, and build it up by spiking 2 by 12-in.

planks together up to the desired dimensions, placing the planks parallel with the face or front of the mortar (not parallel with the ends). This will give an opportunity to make repairs to the block, or to renew any anchor bolts that may ever require it. Experience has shown that repairs of this kind are not easily made if the planks of the block be set parallel with the ends of the mortar.

Some engineers advise filling in the pit with concrete around the mortar-block. This will, of course, insure stability, but it also insures against making any repairs to the mortar-block without going to the expense of shooting out the concrete and thus exposing the wooden block.

In my opinion, the best way is to dig the pit at least 30 in. wider, on both front and back, than the space required for the block, which will give the necessary room for workmen when making repairs in future years. The pit need be but little longer than the length of the block itself.

In case a wooden block is to be set on a foundation of concrete 16 or 18 in. in thickness, it is best to first lay about 12 in. of concrete and on this place a mixture of sand and cement—3 parts sand to 1 part cement, which makes a very firm and enduring monolithic base.

Carefully chamfer the base of the wooden mortar-block on all sides, cutting away about 1 in. at the bottom, and gradually sloping it to the edge 4 in. above the bottom. Make a form of light boards (1 in. by 4 in.), battered so that they will be just the size of the chamfered lower edge of the mortar-block.

When the concrete and sand foundation has been laid as above suggested, place the wooden form in the position that is to be occupied by the mortar-block, and wedge it firmly in proper place. Then fill the space outside the frame with a grouting of cement-mortar, bringing it even with the top of the form. Allow this grouting to set, after which the form may be removed, leaving a depression on the top of the concrete block. Cover the bottom of the depression thus made with clean sand to the depth of 1 in., and the foundation will then be ready for the lowering of the mortar-block. This should be done by means of chain-blocks, the mortar-block so suspended that its top is level, and it is very necessary that when the block has reached the bottom of the pit that it enter exactly the depression made for it on the top of the concrete base. Every care must be taken to prevent loose rocks, dirt, or other foreign substance from falling into the pit before the mortar-block is lowered into position.

Some mill builders set up the battery frame before lowering the mortar-block into the pit, and without doubt, this is an excellent way, and dispenses with the necessity of a derrick or gin-pole. They build the mortar-block and finish it on the surface, anchor-bolt pockets, the chamfered edge at the bottom, and they even sometimes surface the top. The block, when completed, is moved into position exactly opposite the pit which is to receive it, the pit having first been covered with planks to prevent anything falling into it. The block is then raised by means of jacks, or otherwise, to an angle of about 45 deg., after which it is pulled into vertical position by means of block and tackle, the base resting upon heavy timbers placed across the pit to hold it. A 12 by 12 timber is then laid on top of the battery-posts and chain-blocks made fast beneath it, to lift the mortar-block clear of the timbers upon which it rests, and to control its descent into the pit when all is in readiness. The line-sills are then drawn up tightly, clamping the mortar-block firmly into exact alignment. The timbers and planks beneath the suspended block are carefully removed from over the pit, and when sure that nothing has fallen into the pit that would prevent the mortar-block from setting squarely on the base prepared for it, the block is allowed to slide downward, by easing up on the line-sills and operating the chain-blocks. When the block, at last rests on the concrete foundation the task is completed. The space around the block should be solidly filled with sand and water poured in to make the sand settle solidly. If tailings direct from a mill in the vicinity can be sluiced in so much the better.

### Battery-Post Construction

In this it is merely desired to call attention to the advantages of the four-post frame for units of 10 stamps, over three-post construction, though the latter are by far the more common. In the three-post frame the bull-wheel is at one end of the camshaft, and no matter in what direction the power is applied by the belt, there is a tendency to lift the camshaft out of the box at the opposite end from the bull-wheel, the bearing nearer the wheel acting as a fulcrum. The effect of this is to cause the cam-shaft to vibrate unnecessarily; to loosen the cam-shaft boxes; break up the babbitt-metal and eventually to twist the cam-shaft in two. True, this latter may never happen, particularly if the shaft be of liberal dimensions, but the tendency is in that direction, nevertheless.

If the 10-stamp battery be constructed with four posts, having the bull-wheel keyed between the two center ones, the pull of the belt is equalized as nearly as it can be and the vibrations of the cam-shaft are reduced to a minimum. I have never heard of a broken cam-shaft in a mill built in this manner. The slight additional disadvantage of removing the cam-shaft for the purpose of replacing cams, or for any other reason, due to the fact that the bull-wheel cannot first be removed, is more than offset, in my opinion, by the advantages that the 4-post construction affords.

### Height of Discharge

By height of discharge is meant the difference in level between the top of the die and the bottom edge of the discharge surface of the screen. A high discharge tends to retard the escape of the pulp from the mortar; increases the opportunity for the gold to be taken up by the quicksilver in the mortar because of the delay in the escape of the pulp; and it also promotes sliming, which in some ores is very undesirable.

To prevent the sliming of such ores, and at the same time free the gold so that it may amalgamate, a low discharge may be used with a finer screen. This will cause the ore to be crushed finer, freeing the gold from the rock, thus aiding amalgamation, while at the same time affording opportunity for a rapid discharge of the pulp, lessening the liklihood of sliming, which usually results when the pulp is held in the mortar by the high discharge.

When the best height of discharge for any particular ore has been learned by trial, and it can be learned in no other way, this height of discharge should be maintained as nearly as possible. This may be done by the employment of narrow strips of wood under the chuck-blocks. These are removed, one at a time, as the die wears down. It is usual to make these strips about 1¼ in. in thickness.

### Screens

There are a great many kinds of screens on the market, some of them most excellent, too, but after all it is difficult to get a screen that is generally better and cheaper (that is, cheaper for the tonnage crushed through them) than the old-fashioned tinned needle-punched screen. It is a good idea to experiment with a variety of screens, for with certain ores some screens give better results than with others. For instance, a flinty ore that under the stamps breaks into splinters and flaky fragments, will discharge better through a slotted screen, or even one of woven wire, than through a needle-punched screen. Such ores, however, are uncommon.

For granular ores the old-time tin screen is good enough, and records of ½ to ¼ cent per ton have been frequently made with them, and if they are properly treated before being tacked to the screen-frame, and then suitably mounted, the life of the screen will be prolonged and usually will be all that could reasonably be asked. The tonnage cost will be found to be quite as low as with any other kind of screen, and lower than with some others. Before placing the tin screen on the frame the sheet should be held over a bright fire, such as can easily be produced in any blacksmith's forge, and heated to redness. This burns off the tin and anneals and toughens the iron. When burning off the tin keep the screen in motion so that the heat will be applied evenly over the entire surface, taking care not to burn the metal as this damages it and its life will thereby be greatly shortened, for it is almost certain to break long before it is much worn.

To make any battery-screen more enduring, place strips of thin sheet-packing about an inch in width between the screen and the wood of the frame and the screens will last much longer, thus saving in the cost of the screen and in the time required to fit them to the screen-frame. Always buy those tin screens having an unperforated edge on both sides. Tin screens are mostly made in Germany and are made in large and small sheets. Mill screens made by cutting up large sheets are unsatisfactory, as at least one side has no selvage, and that side will quickly break after being put into service.

### Liners

All mill mortars should be provided with liners, and of late years all well-designed mills are thus equipped. Old mills not thus arranged may be provided with liners of some sort. I have had liners made of ⅜-in. steel plate to place in the mortars of a mill that were badly worn on all sides. These plates answered the purpose admirably, as well, in fact, as cast-iron liners would have done. Many old mills are without liners and the mortars are, in consequence, badly worn and daily become worse simply because the mill man does not know that he may remedy the difficulty by the exercise of a little ingenuity in making room for liners.

Mr. W. J. Loring, in Trans. A. I. M. E., Vol. XXVIII, 1898, thus describes the condition at one time in the Utica mills at Angels Camp, California, and the manner in which he overcame the difficulty: "The mortars in the mill were not lined, in fact, were not made for lining. After using them for several years it was found necessary to do something very quickly, as each end was worn, just above the dies, to ⅜ in. in thickness, which, of course, would not stand a great while. These stamps were set 10 in. between centers, using 8½-in. shoes, and leaving a space of 1½ in. between each two shoes. The dies, 5 in. in height, up to that time, had a life of 59 days, the life of the chrome-steel shoes then used being 191 days. The average number of stamps running per day for 333 days in 1896 was 57 out of 60, and they crushed 273 tons per day. In order to line these mortars I found it necessary to reset the stamps, using a guide 9¼ in. between centers, and leaving ¾ in. between the stamps. In this way 1½ in. was gained at each end of the mortars, allowing room for an end liner, which served as a key to the front and back liners. The back was filled with wood, carefully fitted in place, with the liner outside, saving considerable weight in unnecessary iron. This back lining is 13 in. high and stands at 77½ deg., the foot being 1½ in. from the base of the die, which causes the rock, as it is fed into the mortar, to fall on the die. These dies are made with 8¾-in. face, while the shoes have but 8½ in. This I have found to give better results than when both shoe and die are the same size, for the reason that the stem guides are bound to wear, allowing the stamp to swing. A play of ⅛ in. in the guide will allow the stamp to swing much more at the shoe, causing the shoe to overhang the die. Now, by having the die cast ¼ in. larger than the face of the shoe, we utilize the full crushing surface of the stamp. On the other hand, if the shoe and die have a greater difference in diameter, the one having the larger diameter will cup in wearing, causing a loss in efficiency. After making the above changes the mill ran 320 days; average number of stamps per day 59; average number of tons crushed per day, 296; average life of 5-in. cast-iron dies, 120 days; average life of manganese steel shoes, 296 days."

It will be observed from the above that the life of the dies was doubled, and that of the shoes increased by 50 per cent, and that the tonnage crushed was also materially increased by lining the Utica mortars. It would seem that there is a decided advantage in setting the shoes as close as it is safe to set them without interfering, but in doing this it is very necessary that the guides be in first-class condition, not having too much play, or they will interfere and stamp-heads, and sometimes bosses, will be knocked off. The longer life of shoes and dies may be attributed to the better protection they received by having the ore fall directly on the dies, and the increased capacity to this same cause, and to the narrowing of the mortars by inserting the liners.

Where possible shape and fit liners so they can be inverted when one edge is worn, thus getting the full benefit of the value of the material of the liner, otherwise it must be thrown away when only half worn.

### Width of Mortar

For rapid crushing use a narrow mortar. For ore that amalgamates with difficulty use a wide mortar, which discharges more slowly and gives the gold a chance to amalgamate, but do not forget in this matter what was said above under height of discharge and screen mesh. It is not necessary that the back of the mortar be the same distance from the edge of the die, as the distance from the opposite side of the die to the screen. The crushing capacity of a stamp-mill will be found to have about reached the maximum with a given screen and height of discharge when the distance from the die to the back liner is about 2½ in., and from the front edge of the die to the screen about 5½ in. The back liner should incline backward at 75 to 77 deg. Under no circumstances overfeed the mortar for this not only clogs up the screen, thus decreasing capacity, but it also endangers the screen, which is likely to be broken.

### Stamps and Cams

The higher the drop of the stamp the greater the splash and the more rapid the discharge, but there are limitations to the height of drop when speed of revolution of the cam-shaft, which controls the rapidity of drop of the stamps, is considered. I have known stamps to drop 110 times a minute, using double-arm cams, but the height of drop was only 4½ in. With single-arm cams a still more rapid drop is attainable without danger of camming, but single-arm cams are seldom if ever seen these days, though they were quite common in the early history of milling in California. I doubt if one can be found in the State at the present time.

In the early days those favoring the single-arm cam claimed for it that by its use it is possible to bring the cam-shaft nearer to the stamp-stem, thus permitting the commencement of the lift of the stamp to begin closer to a point directly over the center of the cam-shaft. I do not quite follow this reasoning, for I can see no reason why a cam-shaft equipped with double-arm cams may not be brought as near the stamp-stem as one having single-arm cams. In 1867 there was a mill at Austin, Nev., known as the Mettacom mill. It was equipped with single-arm cams. The stamps, weighing 900 lb., dropped 10 in. from 98 to 105 times a minute, and it was officially reported by Dr. R. W. Raymond that it ran at this rate for months and never broke a cam. It was a dry-crushing mill, and was built with unusual care for those early days.

Cam-shafts should be of liberal size—5 to 6 in., according to the weight of the stamps and speed of running. Cam-shaft bearings should be broad—10 to 12 in. Cast-iron covers for shaft boxes are unnecessary, but some mill men tack a piece of canvas to the battery-post in such manner that it will cover the box and keep grit out of it. Some mill foremen do not even babbitt the cam-shaft boxes, preferring smooth iron bearings. If the boxes are not well lined up and are babbitted the babbitt-metal is certain to break up from the concussion of the falling stamps, and the pieces of broken babbitt will usually drop down into the mortar, contaminating the amalgam and interfering with amalgamation.

### Temperature of Battery Water

A great deal has been written on this subject, but I think the majority are agreed that a temperature of 50 to 60 deg. F. gives the best results in plate amalgamation. If below 50 the mercury is too cold to do the best work, and if above 60 it is too thin and is likely to form small globules on the outside plates, which accumulating, may run off the plate, and if not caught in a mercury-trap at some point below, is lost. In the summer months, when the battery water may get warmer than 60 deg., it may be reduced in temperature by pumping it up into a cooling tower, where, in falling through the screens the temperature is lowered several degrees by the rapid radiation of the heat.

### Amalgamating Plates and Tables

Here is another subject over which there is great divergence of opinion, that is, the grade and manner of arranging the outside amalgamating plates. The differences of opinion are principally over the following: Divided plates vs. single sections; drops in the plates vs. no drops; raw copper plates vs. silver-plated copper plates; fixed plates vs. those that are movable and methods of cleaning up.

I never could see any advantage in divided plates. If the entire stream of pulp from a mortar be diverted from the whole surface of a plate to half that area, the result most likely to follow is the scouring off of amalgam already deposited there with very little deposition of new amalgam during the period of overloaded plate.

They who think divided plates the proper thing will, perhaps, argue that the time saved in dressing the plates amounts to more than the loss of the gold. With this argument I do not agree. In the first place there is the danger of the loss of gold already on the plate, and to this may be added the probability that little amalgamation takes place on the overloaded plate. The mill men are paid by the day and therefore their time would be as valuable doing something else. I think most mills have insufficient plate area and a division of the plates results in making a defect worse, and for this reason divided plates are undesirable. There may be places where they would be an advantage, but I have never seen such a place. Some think that divided plates should be used where the ore is very high grade and plates require to be dressed frequently. I should think that the losses would be greater where rich ore was being milled than where the rock was low grade.

Drops, or steps, in the plates, if not too high, are advantageous, as they have a tendency to keep the quick bright and to break up any small balls of sulphides and amalgam that sometimes form and roll away down the plate and are lost unless caught in a mercury trap or on the concentrators. Drops of ½ in., or at most not more than ¾ in., will be found to result in an accumulation of amalgam immediately beneath the drop.

Since this is a well-known fact I have sometimes thought that it might be a good idea to arrange the entire plate area with this fact in mind, constructing the plates of narrow strips of silver-plated copper plate arranged in a series of drops each ½ in. or ¾ in. in height. Make the strips 3 in. wide. If this were done it is quite possible the grade could be lessened from 1¾ in. per foot, which is about the average grade of mill-plates, to ½ in. per foot.

This arrangement in a table 12 ft. in length would give 48 strips each 3 in. wide, and 47 drops of ½ in. each, a total of 23½ in. in the drops, plus a grade of 6 in., in the 12 ft., making a total fall of 29½ in. This would give the series of plates an angle of about 12 deg. The amount of grade, whether ½ in. per foot, more or less, should be determined by experiment. The series of plates could be arranged in sections, say 18 in. each, and so constructed that they could be removed from a frame in which they rest and taken to the clean-up trough for the removal of the amalgam.

There are many who will at once condemn this idea, if for no other reason, because it is something new and untried, but it seems only rational to think that if drops in mill-plates at intervals of 2 to 4 feet are advantageous (and it is well known that they are, as amalgam collects in greater amount just beneath the drops than on the plane surface of the plates), then mulitple drops would collect amalgam at as many places as there are drops, and they would therefore be an advantage.

I recently saw a patented amalgamator of cast-iron circular segments arranged in a series of descending steps, and it is said to be an almost perfect amalgamator. It has no copper plates at all, but quicksilver is placed in the annular depressions which form each step of the device, and it is in these that amalgamation takes place.

In these days there are few who will claim any advantage for raw copper plates over those that have been electroplated with silver though when these latter were somewhat of a novelty there were many mill men who candidly expressed a preference for raw plates, and adhered to that idea for many years. Raw copper, if pure and well annealed, makes an excellent plate after it has been broken in, that is to say has accumulated a good coating of gold-amalgam which the mill man does not scrape off with a steel chisel each time he cleans up, exposing the copper, and making it hard to again get the plate in good condition.

As to the matter of the grade for mill plates, no arbitrary grade can be prescribed. Each mill man must work out this problem for his particular case at each mine, or with each different ore, for there is a vast difference in ores, and the facility with which they will amalgamate. Some ores require a heavier grade than others for their proper treatment by this method. Well designed plate-tables will be provided with means for changing the grade, either by the use of adjusting screws or by means of wedges. This will permit some latitude in the grade of the plates. The grade most commonly given plates in California mills is from 1½ inch to 1¾ inch per foot of the plates, not counting any drops that the plate may have. In a few instances the grade is heavier than this, being sometimes as much as 2½ inches per foot. This is very heavy and may not give the best results. Generally speaking, the proper grade is that which will keep the plate free from accumulations of sulphides, but if too heavy the rushing sands will scour the plate. A series of experiments will soon determine the proper grade for any particular ore.

The last thing: fixed or movable plates, is a matter of less consequence than some of the other things here referred to. Undoubtedly it is an advantage to be able to stand up in front of a mortar when placing shoes, dies or liners, or when removing the sands from the bottom of the mortar, instead of kneeling on a board thrown across the table. The tables can be built with a movable section at their upper ends, next to the mortar. This section, which should extend the full width of the plate-table, need not be more than 30 inches wide in the direction of the flow of the pulp. Its upper end should pass beneath the lip of the mortar, and the lower end extend out over the upper end of the fixed portion of the table, which it is best to have securely fastened to the floor. Such an arrangement as here described greatly lessens the hardship of working in the mortar box for any purpose whatever, and as it expedites work is economical and should be provided. When it is to be moved back out of the way, the men can pick it up and lay it over the stationary table.

As to the use of chisels on mill-plates when cleaning up, I see no objection to the practice if the chisels are handled with good judgment by the mill man, but it is injurious to the plate to dig into it with the sharp corner of one of these chisels made by bending an old rasp into the form of a hoe, or gouging the plate in any manner, as I have frequently seen done, in the effort to secure a little more amalgam. Even one of these chisels, ever so vigorously handled will not scrape gold amalgam from a silver-plated copper plate where there is none to be had, though I have often seen it tried, even sweating with hot blankets and scalding water, to say nothing of the gasoline torch. This latter practice is very bad, as it warps the plate and unfits it for further service, and its employment can only be justified, if ever, in making the last cleanup that it is ever expected to make on those plates. I have noticed, however, that the damage to mill plates is usually done in those mills where amalgam is disgustingly scarce. I have found that there is no instrument more satisfactory for cleaning mill plates than the glazier's putty-knife. It is broad, pliable, and easy to handle and will take up amalgam as well as any other kind of knife or chisel I have ever seen used for this purpose, and it does it, too, without injury to the plates.

When good ore is milled for a long time in any mill, the plates always absorb more or less gold, and in time they become rich with it. This is a subject, too, that has been frequently discussed. However, I will cite but a single instance that came within the range of my own observation: In a certain mill that had been in operation for 11 years, a new manager came in and as the ore those days was rather low-grade he decided to make a thorough clean-up, something that had never been done at this mill. The result was he recovered about $5,000 to the battery. Some of the gold came from old screenings, some from an old ditch-line through which tailings had run to waste, but by far the larger part of it was taken from the plates which for the first time were sweated and scraped with chisels. A large quantity of high-grade ore had been milled in this mill prior to this episode in its existence, and the new manager came from a district where it was the custom to gouge for every last cent in sight, each time clean-up day came around. It is needless to say in this connection that replating of the mill plates in that mill was of common occurrence. Also, it probably never again became possible to repeat the operation of the new manager at the mill where he made the big find in stored-up amalgam of which the owners had not the slightest suspicion until their attention was called to it.

### The Ore-Bins

There is a curious diversity of opinion as to the relative utility of flat-bottomed bins as compared with those having sloping bottoms. Some compromise by building bins that are partly flat and partly sloping.

A flat-bottomed bin affords storage capacity, but should the supply of ore run low, as soon as the angle at which the ore will run down to the chute doors by gravity is reached, men must be put in the bin to pick and shovel the ore down. When the flat floor is reached, if the bin be of good size, some of the ore must be handled at least twice to get it into the feeder chute.

To me it seems that the best place to keep a reserve of ore is in the mine and not in the mill bins. In a mill of 40 stamps, a bin that will hold 1200 tons of ore just as it is delivered from the cars or drops from the breaker floor, is a large bin—few of them are large enough to do it as ordinarily built. In the average California mill this amount of ore will keep the mill of 40 stamps supplied for not longer than six days, while the amount that will run from a full bin to the chutes by gravity is usually not greater than 700 tons in a bin of this size, leaving 500 tons to be shoveled in the event of the supply from the mine running low.

Flat bins are, perhaps, easier to build, but they require more lumber than bins having a sloping bottom. Rock will run quite freely on a slope of 40 degrees, if not clayey, and will come to a state of rest at 35 or 36 degrees, the angle varying somewhat with the material. If the bin is built with a bottom having a slope angle of 35 degrees a few inches of ore will lie on the bottom and thus protect it from the abrasion of rock falling from above. The small amount of ore lying on a slope of this kind can easily be worked down in case it is needed.

When an ore-bin of any shape is filled the movement of the ore at the front of the bin appears to be vertically downward toward the chute door. The result of this movement of the ore is to wear out the planks of the bin for a considerable distance (3 or 4 feet) immediately above the chute door. This may not be noticed at first, but in time it will be seen that the continued abrasion of these places will eventually cut the plank lining in two. This may be avoided by spiking sheets of steel—old turn-plates from the mine, the sides of worn out cars or skips, or anything else of the kind that will afford protection to the lumber of the bins. This protection costs nothing but the trouble of putting it in and will save considerable expense in relining the bin.

In some mills it is evident that it has been considered the most feasible plan to place the rock-breaker in the mill, on an independent frame of heavy timbers. This idea is all right, though it is better still to put the breaker in a separate building if possible. However, if the breaker is to be placed in the mill, and on a separate foundation, do not make the mistake of carefully tying this breaker-frame to the ore bins, and thus to the rest of the mill to give it solidity, nor for any other reason. I have seen this done and could never understand why any millwright, even a very ordinary one, would ever do such a foolish thing.

Where it is possible to conveniently so arrange it, two breakers in series, one set to break to 3 or 4 inches, the other to $1\frac{1}{2}$ inch or less, are desirable, as it increases the capacity of the stamps. This practice is becoming more common as its advantages are better understood. There are some engineers who contend that it is not economical to crush rock in breakers to a size smaller than $2\frac{1}{2}$-inch, but it is my opinion that the limitations in that direction should be determined by the character of the rock rather than by a fixed rule.

### Some Important Negatives

Here are some of the important things that should not be done:

Don't overfeed the mortar, but so adjust the feeder that it will supply the proper amount of rock, protecting the die and securing the largest capacity under existing conditions.

Don't turn too much water inside the battery, and add none at all on the outside plates.

Don't allow sand to accumulate in ridges and islands on the surface of the plates. If it does so promptly sluice it off, being careful not to use too strong a stream of water. If the sand again accumulates sluice it off again and then investigate the cause of it. It may be that the character of the ore has changed somewhat; that the water supply of the battery has been diminished from some cause, or it may be for some other reason, the cause of which must be discovered if possible. It may be that the grade of the plates will have to be increased a little.

Don't permit dark greenish, or bronze-colored spots to remain on the plates. Should any such appear, they are most likely to be due to the presence of soluble sulphates or free acid in the ore or water, or to the presence of some mineral not heretofore noticed. Grease also causes spots to appear on plates, and so does lead or babbitt-metal in the battery. Antidotes for these spots are: Strong solution of salt (NaCl), solution of potassium-cyanide, sodium amalgam, and not the least, a vigorous scouring of the plates with mercury and a suitable cloth. The proper remedy must often be determined by trial, but the last one above suggested is often worth as much as all the others combined, and is a wonder in securing good results.

Don't imagine the mill will run itself after it has once been adjusted, for it will not. Don't neglect the battery. Keep close watch over the entire line, both stamps and plates, that anything that may be going wrong may be quickly detected and the proper remedy applied.

Don't gouge plates with steel chisels to secure amalgam where none is to be had, it is bad for the plates and sometimes for the mill man.

Don't fix an arbitrary time for dressing plates. Dress them when they require it, and in some mills this is often.

Don't lay all the difficulties of amalgamating onto the ore, or on the machinery. It may be the water used in the battery that is at fault, particularly if the water be from the mine. I have known of a mine being condemned because the mill men could not amalgamate the gold, and some time later this same ore was hauled away to a custom mill and gave excellent returns and was found to be free milling to an unusual extent. Inquiry developed the fact that the water used in the former trial was from a mine in which there was a noticeable amount of arsenic.

Don't be afraid to have plenty of plate area. If gold can be taken from the last foot or two of plate the probability is that some gold is escaping the plates altogether, and more plate surface would be advisable.

Don't imagine you know it all. Study the operating conditions of your mill and see if they cannot be improved. In many cases they can be, Be wide awake, take one or more technical papers and keep posted, as the saying is, as to the latest and best practice. Often failure has resulted from lack of knowledge of some simple thing unknown in your own experience or in your district, but which is well known elsewhere.

Berkeley, California.

## Blast Furnace Blowing Apparatus

BY J. E. JOHNSON, JR.

The power first applied to blowing furnaces was that of water wheels, but something over a generation ago these passed out of use except at very small plants working under peculiar conditions, on account of the lack of water powers of sufficient capacity to drive furnaces with the increasing volumes of wind desired and increasing pressures which those volumes necessitated. This brought about the introduction of the steam engine for blowing purposes. The number of types of such engines, and the method by which they were applied to blowing purposes was almost unlimited.

About thirty years ago one type became predominant and held the lead for a long term of years. This is known as the long cross-head type, it consists of a vertical steam-cylinder with a vertical air-cylinder immediately over it, both pistons being connected to the same piston rod. The shaft passes immediately underneath the center of the steam cylinder with a fly-wheel at each end just outside the bed-plate which supports the whole. These fly-wheels carry crank pins exactly in line with one another so as to act as one.

The cross-head is fastened to the piston rod midway between the two pistons and extends parallel with the main shaft far enough for the wrist pins on its ends to come in line with the crank pins in the fly-wheels. The housings which support the air cylinder from the bed-plate are cut out in the center so that the cross-head can pass through and carry on each side of the opening the slides which guide the latter and take up the horizontal component of the thrust of the connecting rods.

Modern designs of this type of engine are shown in Figs. 1 and 2. This engine has the advantage of securing a direct transmission of the stresses arising in the work of compression directly from one cylinder to the other, and also of having its pistons move in a vertical line and therefore avoids their dragging on the bottoms of the cylinders with resultant friction and wear, a condition which at one time was considered unavoidable with horizontal engines.

This engine is also compact, it requires only a small foundation and small space in the engine house. It is under the disadvantage of requiring two connecting rods, and of requiring very careful workmanship in securing the absolute correctness of alignment of the two crank pins. It also labors under the disadvantages in regard to supervision to which all vertical engines are subject. The advantages were long sufficient to outweigh the disadvantages and this type of engine held an absolutely predominant place for a long term of years, and while changes in the conditions have brought about the development of many other types, these engines, when of modern design and economical type, are not only kept in use but new engines of this type continue to be built in considerable numbers. It is, therefore, with the development of this type that the modern blowing engine has its real beginning.

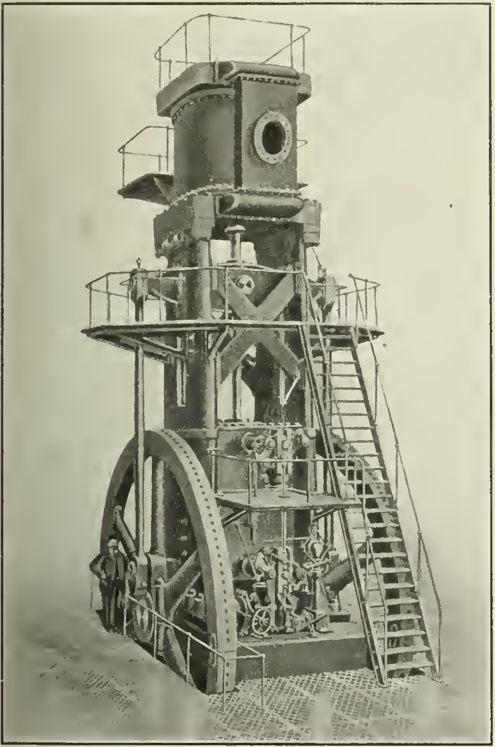


FIG. 1.—SOUTHWARK VERTICAL LONG CROSSHEAD BLOWING ENGINE

At the time when these engines obtained their predominance outputs per furnace were small with consequent small requirements for volume of blast and pressures were quite low, probably, on the average, less than one-half of what they are to-day.

As a result the power required per furnace was small and economy as I pointed out in the last article was a factor almost absolutely ignored. The small blast volume required made it possible for few engines of moderate size to supply the blast required for a furnace at a very moderate speed. Hence, there was little or no demand for high speed to cut down the number and size of engines required.

Under these conditions engines were always fitted with some type of self-actuating air valves, in which a slight difference of pressure within and without the cylinder operated both the inlet and the outlet valves in the required direction, and when this difference in pressure was ended and then reversed, as the piston reached the end of its stroke and started on the return, these valves were closed by the return currents of air so set up.

With low pressures and moderate speeds these conditions of operation produced no bad results, especially as the pressure and temperature to which the air was raised by compression were low and therefore valve faces and piston rings could be made of leather and wood respectively, or of other natural fibrous materials. These materials, however, while perfectly satisfactory at low temperature, undergo chemical change with increasing rapidity as the temperature rises and so the time came, as pressure increased, when such materials could no longer satisfactorily be used for these purposes.

This forced the substitution of metal faces for these valves and thus emphasized the two difficulties with automatic valves, the understanding of which had gradually come to pass. First, if these valves are operated entirely by the currents of air which pass through them, they do not seat themselves until these currents are reversed in direction, and then are brought to their seats with a violent shock at any but very low speeds. As long as leather could be used this shock was much cushioned by the leather, but when metal faces became necessary operation under these conditions became increasingly difficult.

Second, the area within these valves on which the excess pressure operates tending to lift them from their seats is less than the area without them tending to hold them closed, by an amount equal to the area of the seat itself, which must always be a considerable percentage of the total area. Therefore, the pressure within the valve must always be greater than the pressure without it, in the inversed ratio of the internal and external areas, before the valve will open. This leads to a delayed operation of the valve and necessitates much greater difference between the internal and ex-

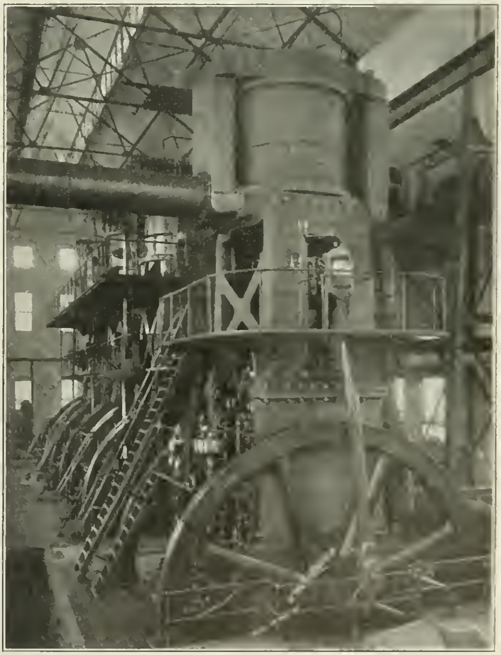


FIG. 2.—INSTALLATION OF "MESTA" LONG CROSSHEAD STEAM BLOWING ENGINES

ternal pressures than would otherwise be necessary with corresponding loss of power.

If in order to overcome the difficulty of having the valves slammed hard against their seats by the reversed currents, a weight or spring was applied to them to force them to their seats, the pressure due to this weight or spring must be added to the difference between the internal and external pressures, with corresponding further loss of power. It is obvious that as pressures rose and speeds increased these difficulties must be augmented.

There were also other conditions of great importance to be met. First, the clearance should be kept small so that as nearly as possible all the air displaced by the piston may be driven out through the discharge valves instead of simply being compressed into the clearance space, and then re-expanding at the beginning of the next stroke, to the exclusion of air which should be taken in from outside.

Second, the area of the valves must obviously bear a definite ratio to the area and speed of the piston so that a valve area which is quite sufficient to permit relatively complete filling and ready discharge of a given cylinder at a low or moderate speed may be quite insufficient for the same cylinder at a higher speed. It must be remembered particularly in this connection that these losses are frictional and, therefore vary as the square of the velocity, so that a cylinder which will fill with two ounces of suction at thirty revolutions will require one-half a pound at sixty, and a pound and one-eighth at ninety.

To meet as well as possible these conditions of low clearance and large area, a great multiplicity of valves, both for inlet and discharge were adopted, and this was standard practice for many years, there being more than a hundred such valves in each end of an air cylinder of moderate size, in some designs.

With increasing rate of driving came increasing pressure, and this brought about another difficult condition. It modified the shape of the indicator diagram for the air cylinder very much for the worse, from the point of view of the engine. With a blast pressure of four pounds the piston travels only about 20 per cent. of its stroke before the air is compressed to the required pressure and begins to flow through the discharge valves so that with reasonably good design of valves, the work done upon the air cylinder was quite uniformly distributed throughout the stroke and subject to a minimum of variation. With a blast pressure of twenty pounds the piston travels more than 50 per cent. of its stroke against a pressure which rises constantly more rapidly, with the result that about three-fourths of all the work of the stroke is done in its last half.

On the other hand, the older types of uneconomical steam cylinders used but little expansion and so the steam pressure was but little lower at the end of the stroke than it was at the beginning, and the drop which took place was quite gradual with no sharp or sudden changes.

The demand for increased economy grew, as has been pointed out in the last article, and this could only be obtained by one means, much greater completeness of expansion of the steam. This means that under ordinary conditions nearly one-half of the total work of the stroke must be developed in its first quarter, exactly the opposite to the way in which it is consumed, the greatest portion, as we have just seen, being expended in the latter portion of the stroke.

Some form of equalizer has to store the surplus work done in the steam cylinder in the early portion of the stroke, and give it out in the latter portion, and this equalizer is the inertia of the fly-wheel and of the reciprocating parts, but it is obvious that in a running machine which must have a certain amount of play in its moving parts a complete reversal of the stress from one direction to the opposite, somewhere near the middle of the stroke, could not contribute to its smooth and easy working.

It will be seen from the above that the conditions under which the blowing engine worked in the early days of the long cross-head type grew steadily worse with the development of modern furnace practice. As a consequence of these conditions it is probably safe to say that, next to the furnace itself, blowing engines have given more trouble and furnished more difficult problems to furnace builders and operators than any other portion of the equipment.

## Air Valves

To meet the increasing difficulties to which changing conditions subjected the automatic types of valves many designs of positively actuated valves were brought out, of which the test of time has left but few, and it is not possible in a single chapter to treat any except those which have had some considerable degree of industrial success.

### CORLISS VALVES

The Corliss or semi-rotating valve had proved its serviceability, its relative ease of operation, and its tightness under long continued wear, by almost half a century of successful use in the steam engine, at the time when the development here under discussion began, therefore it is not surprising that this valve should have been one of the first applied to air cylinders. In its earlier form it was applied in almost the identical way that it was in the steam engine, except that the inlet valve in the air cylinder corresponds to the exhaust valve in the steam cylinder, as does the discharge valve of the air cylinder with the inlet valve of the steam cylinder.

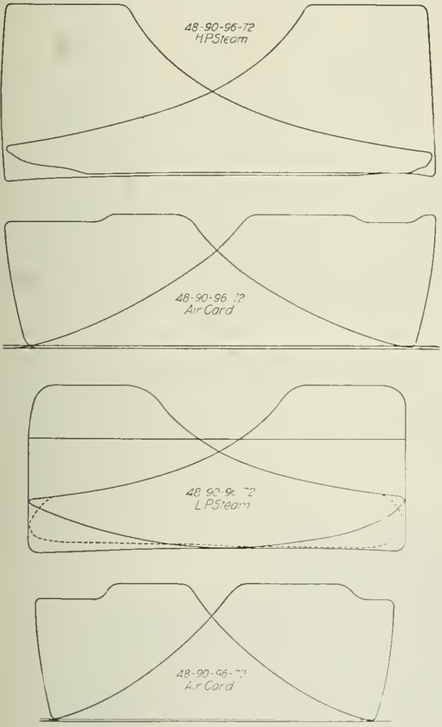
A glance at the indicator diagrams, Figs. 3 and 5, showing steam cards, Figs. 4 and 6 showing air cards, will show that these are of the same general type and shape but one is traced in one direction and the other in the opposite. One represents positive work and the other represents negative work, or energy absorbed. So the base line of one represents spent fluid discharged, and of the other incoming fluid to be compressed.

The inlet line of the air cylinder changes but little with changing conditions, that is to say, the times at which the inlet valve opens and closes are only slightly altered by changes in speed or pressure.

Theoretically the proper time of opening is changed slightly because the greater quantity of air in the clearance space at higher pressures expands to a greater volume at atmospheric pressure, and in order to recover all the energy due to the complete re-expansion of this air the inlet valve should not open until re-expansion brings the pressure of this clearance air down to that of atmosphere, which, of course, means that the inlet valve should open somewhat later with high pressures than with low. But no practical or even appreciable loss is experienced under any ordinary condition, by having this point of opening fixed at the point to suit normal conditions.

For these reasons the inlet valve is positively connected to the eccentric and opens and closes at predetermined points in the stroke. The discharge valve on the other hand ought obviously to open at a different point with four pound pressure from what it would for twenty, and it was long thought that it was necessary to put the opening of this valve under the control of some type of trip mechanism, akin in principle to the Corliss dash-pot, which was released by a small auxiliary cylinder in direct communication with the end of the main cylinder, so that as the pressure in the latter rose, the auxiliary piston tripped the releasing gear and the dash-pot pulled the valve open.

It was left for Mr. B. V. Nordberg, of the Nordberg Manufacturing Company, to point out that the loss by having the discharge open a trifle too soon was almost insignificant, in fact practically inappreciable even with very considerable changes in the discharge pressure, and he therefore builds blowing engines, in which both the inlet and the discharge valves are rigidly connected to eccentrics, timed to open and close them at the proper point for normal conditions. A clause in the contract for the first of these engines provided that if it should be found necessary, an automatic gear would be provided at small additional expense which would shift the point of opening of the discharge valves as the pressure rose, but the results from the engine in practice were almost absolutely perfect, and no conditions ever arose to cause regret at the omission of this automatic device.



FIGS. 3 TO 6.—STEAM AND AIR CARDS

Corliss valves have several great advantages. By a suitable design of valve gear they can be made to perform most of their travel at a time when the pressure on their opposite sides is approximately the same, so that they can be moved with a minimum of power and of wear, and owing to the "dead travel" obtainable with a proper design of wrist plate are almost stationary when the unbalanced pressure upon them is considerable. They are held against their seats by pressure, and follow them down as they wear, with the result that their tightness in service under good conditions is well maintained. They also permit large port areas with minimum clearance.

On the other hand they require a considerable quantity of oil for proper lubrication, and one large set of engines with this type of valves so designed as to require an excessive amount of oil to keep them in operation was probably more responsible than any other one condition for their failure to develop into a leading type of valve. In spite of this fact at least one engine with valves of this type is known to the writer which has been in virtually continual operation for twenty-five years and is in first-class condition now.

### POT VALVES

The poppet type of valve had always been used for discharge valves and one of the first steps in replacing the Corliss valve for air cylinders was the introduction of a modified form of poppet valve which opens automatically, but is positively closed, an idea first brought out by the German engineer, Riedler.

This valve consists of a hollow steel pot drawn from a single piece of steel. This pot is from eighteen to twenty-four inches in diameter and of approximately the same depth, with a spherical bottom surface, the metal in it is about a quarter of an inch thick in the bottom, and three-sixteenths of an inch in the sides. This closes against a suitable seat in the cylinder head close to the piston. Inside of it works a plunger, sometimes this plunger is the same diameter as the inside of the pot in which it acts as a piston, sometimes the plunger is of smaller diameter.

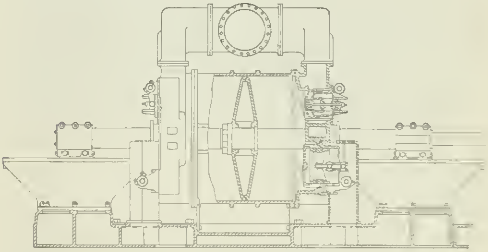


FIG. 7.—REYNOLDS' POPPET VALVE

This plunger is operated by a rock shaft driven from an eccentric so timed that the plunger forces the valve to its seat an instant before the crank passes the center and before any return current of air can be set up from the receiver back into the cylinder. The plunger is then withdrawn and the valve is held to its seat by the excess pressure within it, since it is provided with small holes around its circumference, just above the seat, which put it into constant communication with the air receiver, and which permit the escape of the air between the plunger and the cylinder, thus helping to bring it to its seat gently and without shock or jar.

One of these valves is shown in the upper portion of the right-hand end of Fig. 7. This type of valve has remained the predominant one throughout the period of supremacy of positively operated valves. The original form of this design was the invention of the late Edwin Reynolds.

Various types of air inlet valves were tried, all designed to keep the clearance down to a minimum and yet give ample area for the admission of air, not only to keep down the suction but to secure the complete filling of the cylinder before the beginning of the compression stroke.

Two of these designs were radical and interesting by their boldness. One was known from its inventor, Mr.

Julian Kennedy, as the Kennedy inlet valve. It consists, as is shown in Fig. 8, of a long slender cylinder passing entirely through both cylinder heads and the piston of the air cylinder, with suitable packing rings or glands in all three. This cylinder has near its upper and lower ends a system of ports cut through its walls on long spirals, one set for each end of the air cylinder. This valve is driven by an eccentric so that the ports in it are brought within the cylinder head during the admission stroke. Both ends of the valve are perfectly open to the air which passes in through its ends and out through these ports into the cylinder. The valve was properly timed to open and close correctly at each end of the cylinder.

Fig. 8 shows a design in which this valve is set on one side of the cylinder and presumably in this case there are two of these valves. In the ordinary design there was one valve in the center of the cylinder, and the air piston was driven was driven through two piston rods symmetrically spaced on each side of it, a design which has some merit.

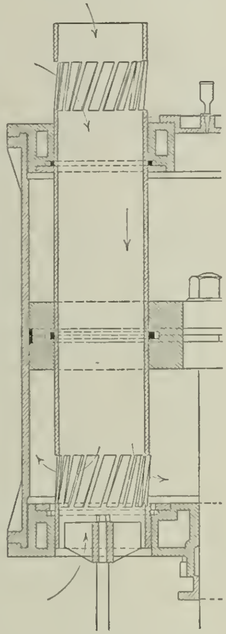


FIG. 8.—KENNEDY INLET VALVE

The other design was the invention of Mr. E. E. Slick, formerly chief engineer of the Edgar Thompson Works, now general manager of the Cambria Steel Company. This was still more radical. The whole cylinder was perforated at each end with a set of ports like those in the Kennedy inlet valve, and this cylinder was moved back and forth by a heavy rock shaft so that during each suction stroke these ports came within the inner surface of the corresponding cylinder head, these being rigidly held independently of the cylinder and making a sliding joint with it like the piston. This obviously gave the whole circumference of the cylinder for a port and yet the clearance due to inlet ports was absolutely nil. This arrangement is shown in Fig. 9, it has been successfully used for a number of years on large and particularly on high-speed blowing engines, but many engineers and furnace operators objected to the awkwardness of the principle involved in sliding cylinder weighing several thousand pounds back and forth through a travel approximating a foot at a rate of sixty, seventy-five, or more revolutions per minute.

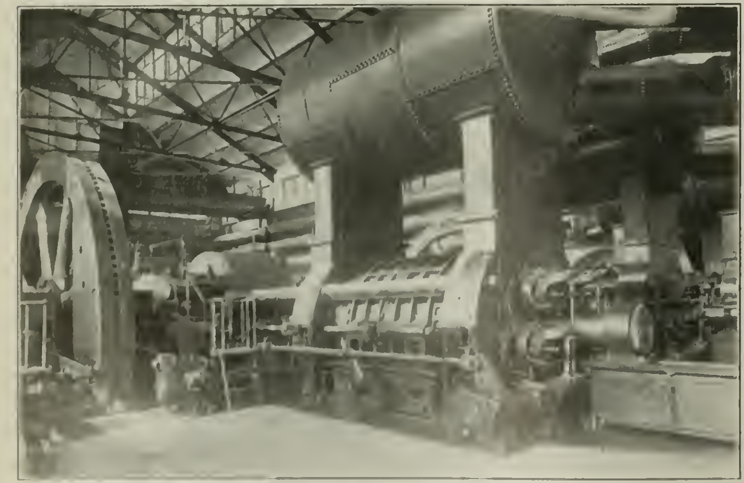


FIG. 9.—SLICK-BLOWING TUBS IN THE CENTRAL FURNACES OF THE AMERICAN STEEL & WIRE CO., CLEVELAND, OHIO

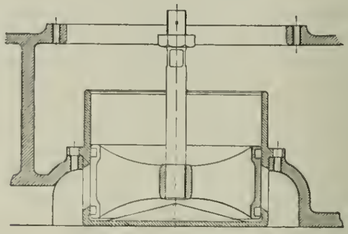


FIG. 10.—KENNEDY PISTON INLET VALVE

The Kennedy valve also was disliked by many engineers and operators because of the great mass of metal to be pulled back and forth through a travel of nearly two feet, and at speeds up to fifty or sixty revolutions, also to the three moving joints necessary in that device, one in the piston, and one in each cylinder head. On several occasions these valves became detached from their driving mechanism and owing to their inertia, due to their weight and high speed, they generally made a wreck of serious proportions under such conditions.

A modification of this valve has been very successful. This is shown in the lower half of the right-hand air cylinder head in Fig. 7 and by Fig. 10. It consists practically of one end of the Kennedy inlet working in a short cylinder set in the main cylinder-head.

The air passes in this case longitudinally through the valve and then outward through the ports in the sleeve which carries it, and so into the main cylinder. The only disadvantage under which this valve suffers as compared with the Kennedy is the slight increase in clearance necessary to carry the air from the ports in the sleeve into the cylinder proper.

The weight of the valve is only a small fraction of that of the Kennedy, and its travel is also much less, so that the inertia of this type of valve is almost insignificant in comparison with the inertia of the Kennedy valve and Slick valve types.

The construction is shown in the illustration.

### THE SOUTHWARK AIR VALVE

The Southwark Foundry & Machine Company had enjoyed for many years the reputation of pioneer builders of high-speed engines, having developed a system of balanced slide valves for the steam cylinder which could be put under the control of a governor, and permitted these engines to be operated at a higher speed than that attainable by any other type of large engine at the time when the modern development of blowing engines began. They also appreciated the advantages of high speed from a purely mechanical standpoint, notably in regard to inertia stresses and the beneficial effects which they could be made to exercise upon the running of engines. This is a subject which we shall presently discuss.

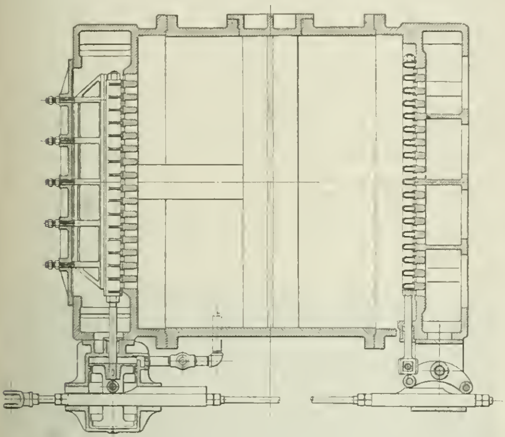


FIG. 11.—SOUTHWARK AIR CYLINDER SHOWING INLET AND OUTLET VALVES, WITH GEAR

These two conditions made it natural that the Southwark Company should desire to extend the benefits of their system of high speed engines to blowing engines, and they accordingly developed a system of positively operated valves arranged to open and close without shock and to provide ample port area for any speed at which blowing engines could be successfully operated. This system uses a multi-ported or a grid-iron valve both for inlet and outlet. The inlet valve is operated entirely by a cam driven by an eccentric. The inlet valve is on the inside of the head and is unbalanced because its movements take place only at times when the pressure on both sides of it is the same. The discharge valve is on the outside of the head and is balanced by a cover plate on its back. This valve is closed at the end of the stroke by a cam attached to the same mechanism as that which operates the inlet valve, but is opened by a small auxiliary cylinder in communication with the main cylinder, when the rising pressure in the latter during compression, equals that in the receiver.

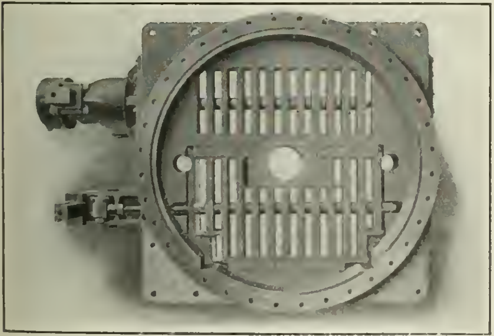


FIG. 12.—SOUTHWARK AIR CYLINDER HEAD, INSIDE VIEW

A longitudinal section is shown in Fig. 11, and views of a cylinder head with its valves is shown from within and from without by Figs. 12 and 13.

It is probably no more than fair to say that this system of valves was the earliest of any of the mechanically operated valves to be developed into its present condition and at the same time remain in general use. It is also probably fair to say that this valve was the first to be used in this country at the high speeds which are absolutely necessary with gas-driven blowing engines, and which are very desirable with many steam engines.

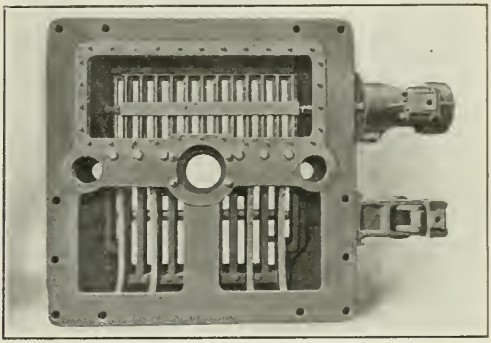


FIG. 13.—SOUTHWARK AIR CYLINDER HEAD, OUTSIDE VIEW

#### The Return to Automatic Valves

The last two or three years have seen a development in this field which brings us back almost to the starting point. The gas engine has received a great development in Germany and as the speeds at which it has to run in order to be successful are considerably higher than those customary with steam engines, the question of air valves has been one of great moment to the German engineers, and they have developed a system which modern workmanship and modern metallurgy has made possible.

Each valve consists of three concentric rings held together by radial bars or bridges, the whole being stamped from a single plate of thin special steel. This is fastened to a flat spiral (not helical) steel plate spring held to its seat by a hole through the center.

The valve seat consists of similar but alternately spaced concentric rings, the openings between which constitute the ports and are covered by the valve rings when closed.

The valve is extremely light in weight and requires but a slight lift to give full opening and its inertia is, therefore, very small.

For this reason the small tension of the flat spiral spring is sufficient to seat the valve at the proper time without adding appreciably to the air resistance in passing through it.

The principle of this valve is not essentially different from that of the poppet valve of fifty years ago, but the details of the design are such as to constitute the difference between failure and success under modern conditions.

The American patent on these valves has been bought by the Mesta Machine Company, of Pittsburgh, by whom they have been redesigned and are being introduced under the name of the Iverson Valve. These are shown in Figs. 14, 15 and 16.

The results with these valves in regard to providing the area necessary for inlet and discharge with minimum suction on the bottom of the indicator card, and minimum excess pressure on its top line, are claimed to be equal, if not superior to, the best of the mechanically operated valves. The clearance is small and the operation of the valves is noiseless.

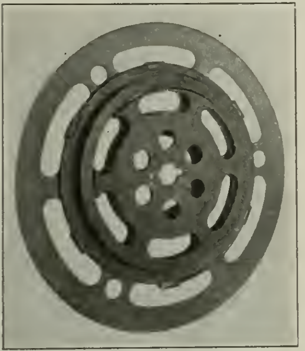


FIG. 14.—VALVE PLATE AND SPRING OF "MESTA" (IVERSON PATENT) AUTOMATIC PLATE VALVE

These valves have one advantage also which I should hardly have believed if I had not seen the results myself. In vertical engines the inertia of the eccentric rods, rock-shafts, and other mechanism for actuating the air valves is sufficient to cause some vibration in almost all engines, and in those of the steeple type this has in many cases been excessive. In cases where these valves have been substituted for mechanically operated valves, the entire absence of any moving parts except these light valves themselves, which only move a distance of an inch or two, eliminates this vibration.

I have seen engines running side by side, one vibrating almost dangerously and the other perfectly still. The manager who was then trying the valves out told me that the engine with the automatic valves had vibrated as violently as the other when it was positively operated.

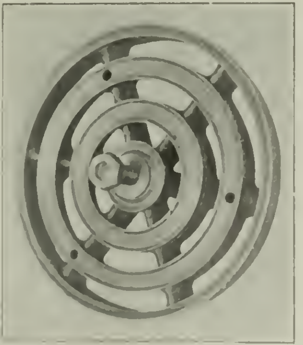


FIG. 15. VALVE SEAT OF "MESTA" (IVERSON PATENT) AUTOMATIC PLATE VALVE

It is probably too early in this new development to say what its ultimate results will be, but if the promise of the present is fulfilled we shall probably witness the elimination of much complicated and expensive mechanism from our blowing engines in the next few years.

### Methods of Compounding

The growth of a demand for economy in blowing engines, previously described, obviously required the introduction of compounding, to which at first sight the long cross-head type of engine did not adapt itself well.

The late John Fritz solved the problem by putting the high and low pressure cylinder of the compound side by side over the shaft in the position previously occupied by the single cylinder, and connected both piston rods to the long cross head, the position and parallelism of this being rigidly controlled by the connecting rods at its outer ends, by which the continually varying differences in pressures in the two cylinders were absorbed apparently without injurious racking stresses on the engine.

A single air-cylinder was used, as with the simple type of engine, its piston rod being connected to the center of the long cross head as before.

This type of engine, however, never received general favor, and, consequently, other types were developed which adapted themselves to compounding. The principal ones of these types are the horizontal cross-compound with tandem air cylinders, the vertical cross-compound with tandem air cylinders, known as the steeple type, the cross-compound horizontal vertical engine with horizontal steam cylinders working on two cranks at right angles with the air cylinders vertically over these cranks and driven by them, the quarter crank vertical engine with steam and air sides entirely separated except for the crank shaft which connects them, and the disconnected compounds.

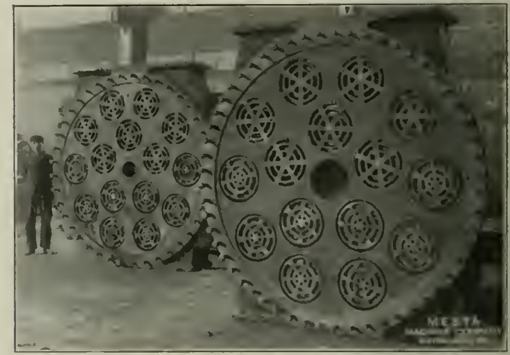


FIG. 16.—AIR HEADS EQUIPPED WITH "MESTA" AUTOMATIC PLATE VALVES (IVERSON PATENT)

Before we can discuss these different types of engines intelligently the subjects of the inertia of the reciprocating parts and engine friction must be briefly treated. The subject, as applied to the steam engine, will be found in any good treatise on that subject, but the steam engine is very different from any type of blowing engine in which the air and steam pistons are connected to the same rod, for the reason that all work generated in the cylinder, in the power engine, has to pass through moving parts, the cross head pin, crank pin and main bearing, into the crank shaft, from which the useful effect is delivered. While in the blowing engine where the steam and air pistons are rigidly connected to the same rods the energy generated in the steam cylinder is transmitted only through a rigid member directly into the air cylinder, except as has been pointed out that most of the work is generated in the steam cylinder in the early part of its stroke, and the principal utilization in the air cylinders occurs in the latter part of the stroke.

It is obvious that the excess not immediately utilized in the air cylinder must be stored either in the fly-wheel or in the reciprocating parts and given out again to make good the deficiency in the latter part of the stroke. The transmission of these excesses and deficiencies through running parts affects seriously the friction of the engine, which is important not only on account of the power so lost, but because the power lost represents destructive energy applied to the moving parts of the engine itself, and for economy of maintenance if not for economy of power, should be kept as low as possible.

It is probably true to say that the friction of a well built reciprocating steam engine is about 10 per cent. of its indicated horse-power at its rated load, and when running idle, but up to speed, the friction is about one-half of this, that is, about 5 per cent of its rated power.

It is obvious, therefore, that if we can take part of the energy developed in the steam cylinder and apply it directly without its having to pass through the running parts to the fly-wheel, we shall make a considerable saving in friction, and, consequently, in wear.

### INERTIA OF RECIPROCATING PARTS

This is not the place for an extended discussion of the subject of the inertia of the reciprocating parts, which is a mathematical problem of no mean order if it be handled completely and accurately. For our purpose, it is sufficient to say that the inertia of the reciprocating parts at the end of their stroke exerts a force equal to the centrifugal force of an equal weight hung on the crank pin, and in the same direction, that is, outward from center of the crank shaft. Starting at this value this inertia diminishes in the same proportion as the distance of the piston from the center of its stroke, at which point the inertia becomes zero. Then, as the piston approaches the other end of the stroke the inertia effect rises from zero to an equal amount in the opposite direction.

It is obvious that this inertia always acts outwardly from the crank shaft; that is to say, at the head end of the stroke it acts toward the head of the cylinder, and at the crank end of the stroke it acts toward the crank end of the cylinder. The fact that this force increases from zero at the center to a maximum at the ends, and then decreases down to the center again on a straight line diagram, should be emphasized, because it is often supposed by those who have not studied the subject that this force is exerted only at the end of the stroke. Nothing could be further from the fact.

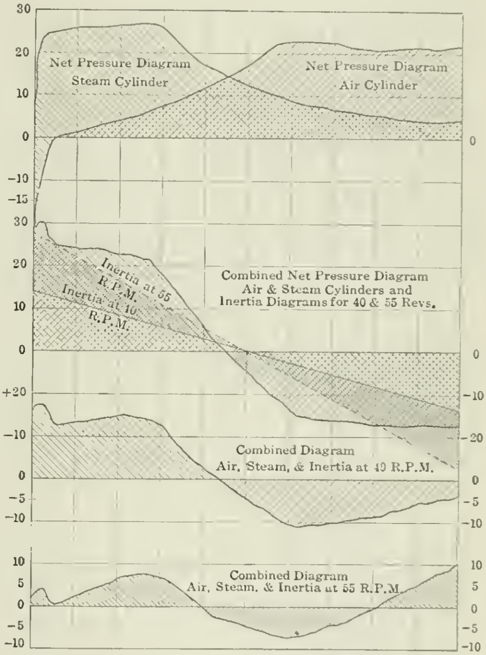
The statement of the exact proportionality of this force to the distance from the center of the stroke is exactly true only when the connecting rod is of infinite length, or when the slotted cross head or Scotch yoke is used, which, of course, is never done with blowing engines. With connecting rods of finite length the inertia effect is greater at the head end and less at the crank end than the amount stated, by that fraction of the whole which expresses the ratio of the crank-throw to the connecting-rod length. This, while a matter of some importance to designers, is not of sufficient importance for our purpose to necessitate its being taken into account, as the assumption of the straight line diagram for the inertia effect is sufficiently accurate for our purposes.

It will be obvious from what has been said that this inertia effect tends to absorb energy from the steam cylinder in the early part of the stroke, when energy is required to accelerate these moving parts, and to give it out again in the latter part of the stroke, when these parts are being retarded by the movement of the crank. This means that the reciprocating parts are taking up energy at a time when the steam cylinder has it to spare, and giving it out at a time when the air cylinder needs it.

In order to investigate this effect quantitatively in relation to the air and steam pressures, it is necessary to determine the total inertia effect and then consider it as distributed over the air piston as if it were a force of so many pounds to the square inch. Similarly, we can reduce the pressure of the steam cylinder in the ratio of its area to that of the air cylinder, and so put all three of these forces on the basis of a common unit, of pounds per square inch of air cylinder area.

Through the kindness of the William Todd Co., of Youngstown, I have obtained sets of indicator cards from the air and steam cylinders of steam blowing engines, and also similar cards from a gas blowing engine. They have also given me the rated speeds of these engines and the weights of the reciprocating parts, as well as the diameter of the various cylinders and the strokes.

These diagrams for a horizontal cross compound blowing engine with forty-eight-inch high-pressure cylinder, ninety-inch low pressure, ninety-six-inch air cylinders and sixty-inch stroke in common are those shown in Figs. 3, 4, 5 and 6.



FIGS. 17 TO 20—DIAGRAMS

These cards were taken to represent approximately simultaneous conditions in all the cylinders. The rated speed of this engine is forty revolutions, the weight of the reciprocating parts on each side is approximately sixty thousand five hundred pounds.

From these I have laid out what may be called the resultant diagrams of all three forces, that in the steam cylinders, that in the air cylinder, and that of the inertia—all reduced to pounds per square inch of air cylinder area, which are shown in Figs. 17, 18, 19, 20.

There are obviously four sets of such resultant diagrams for such an engine, one representing one stroke in each direction and on each side, but as all of these are more or less similar one will be sufficient to show the principle involved.

We first have to convert the diagrams as taken which represent the conditions throughout the cycle of one revolution in each end of each cylinder and convert them into "net pressure" diagrams for the steam and for the air cylinders by deducting from the pressure in one direction, the *simultaneous* pressure into the opposite end of the cylinder in the opposite direction, this subtraction being made in the algebraic sense. These two net pressure diagrams are shown in Fig. 17, the pressures of the air diagram being in the opposite direction to those of the steam diagram. Ordinates below the line represent pressure in the opposite direction to that represented by ordinates above the line.

We can obviously combine these two diagrams into one by subtracting the ordinates of one from those of the other in the algebraic sense. The result of this operation is shown in Fig. 18, which shows that the pressure is entirely in one direction during one-half of the stroke, and suddenly changes to the other near the middle of the stroke. On this diagram is shown, as a solid straight line passing through the center, the value of the inertia per square inch of air cylinder area, for forty revolutions, and in dotted lines that for fifty-five revolutions.

Remembering that ordinates of the inertia diagram above the zero line on the left-hand side of the diagram mean energy absorbed, and those below the line on the right hand side of the diagram mean energy given out, we can obviously deduct these ordinates from the net pressure ordinates of the combined diagram for air and steam, and the result will be the final net pressure transmitted to the crank pin. The result of this subtraction is shown in Fig. 19 for forty revolutions, while Fig. 20 shows the result which would be obtained on a similar basis if this engine were run at fifty-five revolutions instead of forty.

It will be obvious at a glance that the energy represented by the triangular area of the inertia diagram has been subtracted from the energy imparted to the fly-wheel in one part of the stroke and subtracted from that given out from the fly-wheel in another part of the stroke, the result being that the energy transmitted through the running parts at forty revolutions is only about one-half of that represented by the total work done, and would become an almost insignificant amount at fifty-five revolutions.

It may be thought that these considerations are too theoretical to be of practical importance, but I have seen large blowing engines in poor condition which would make a noise almost like steam hammers when running at a low rate of speed, but which would quiet down when the speed was increased until at a speed as high as the valve gear would stand they would run silently and well. Moreover, the Southwark Company has designed blowing engines on this principle for many years which have run as successfully as those of any other maker, and more successfully than those of some builders, who use much lower speeds, because they are afraid of the higher ones.

The Nordberg Manufacturing Company also has built blowing engines, some of them to the specifications of the writer, which were designed on this principle. They had a relatively short stroke, and ran at a high rotative speed, and so obtained the displacement of a much larger engine at a lower speed. These engines were properly proportioned as to the inertia stresses and ran with the most perfect smoothness and absence of all pounding and noise at high speeds, seventy-five and eighty revolutions, as well as at lower ones. These facts have a most important bearing upon the design of blowing engine to be preferred.

### The Disconnected Compound

The problem of compounding blowing engines has been solved in the case of several of the types of engines above described, by building two separate units, one containing the high-pressure steam cylinder, the other containing the low, these units being connected only by the steam receiver. These engines are thus enabled to run as compounds and enjoy the benefit of that system, and at the same time retain the flexibility due to small units, because each engine can be run separately. The high-pressure engine has two dispositions for its exhaust, one to the receiver and the other direct to the condenser, or atmosphere. Then, if the low-pressure engine is not needed, or needs repairs, it may be shut down and the high-pressure then exhaust-direct. Similarly, the low-pressure unit has a double source of steam supply, one the receiver steam from the high pressure, the other, live steam throttled through a reducing-valve, so that this engine can be run entirely independent of whether the high pressure unit is in operation or not.

This type of compounding has been applied to the horizontal tandem, the quarter crank vertical, to the horizontal tandem, and particularly to the long cross-head types of engines. In fact, for several years the long cross-head type of engine regained at least in part its old preëminence through the introduction of this system.

When this system is used one engine may be used on one furnace and the other on another, if desired. Where three cylinders are required to blow a furnace, as is not infrequently the case, six of these units, constituting three complete compounds, blow two furnaces, one complete unit on each furnace, the high-pressure of the remaining unit on one furnace and the low on the other. The arrangement of the valves is such that if one furnace is to be shut down, or if the blast be taken off for even a short time, the exhaust valves on the high pressure can be operated simultaneously, the receiver exhaust being closed while the direct exhaust is opened; the steam valves on the low pressure can be similarly operated so that either half of the unit may be kept going on its furnace irrespective of what the other unit is required to do. The governor operates on the high-pressure cylinder only and the cut-off of the low pressure unit is regulated by hand to bring its speed the same as that of the high pressure. This adjustment will hold for a considerable variation of pressure without very much variation from the desired speed on the part of the low-pressure unit, when both are in one furnace, and, consequently, blowing against the same pressure, but when the two units are used on different furnaces whose pressures vary in different ways, the conditions are not so simple and more frequent adjustment of the cutoff on the low-pressure unit is required.

The writer designed several years ago a means whereby these engines could be made to run at the same speed irrespective of the conditions under which they operated, but the manufacturers took no interest in introducing the device, and nothing was ever done with it.

### Review of Different Types of Engines

We may now review these different types of engines in the light of the general conditions set forth above, and pass on their desirable and undesirable characteristics.

#### THE VERTICAL QUARTER CRANK ENGINE.

This engine, shown in Fig. 21, is built in practically the same design by several of the best builders, and is not, as far as I know, recommended particularly by any of them. I shall not, therefore, do any injustice to any of these builders when I say that in my judgment this is the poorest type of blowing engine in regular use today. A certain measure of accessibility is obtained by the fact that it has no tandem cylinders, but it requires a considerable amount of space, a much larger foundation than a long cross-head engine of the same capacity, and an equal if not greater height, while its running parts are very inaccessible for handling with a crane.

The principal objection to it, however, is that it has two complete sets of running gear with their high first cost and maintenance, and that all the energy developed in the steam cylinder has to be transmitted through running parts into the crank-shaft and then from the crank-shaft through another set of running parts into the air cylinder. Taking the mechanical efficiency of a standard steam engine at 90 per cent and the mechanical efficiency of a crank-driven compressor at the same we have an efficiency in this engine of 81 per cent as against 91 to 93 per cent that may be and is secured in regular practice with the tandem connected machine. It is well to remember that this 21 per cent of friction loss as against 8 per cent in the other case, represents not only a loss of power but an expenditure of energy for destructive purposes which must reappear in the form of wear of two sets of heavily stressed running gear instead of one set lightly stressed.

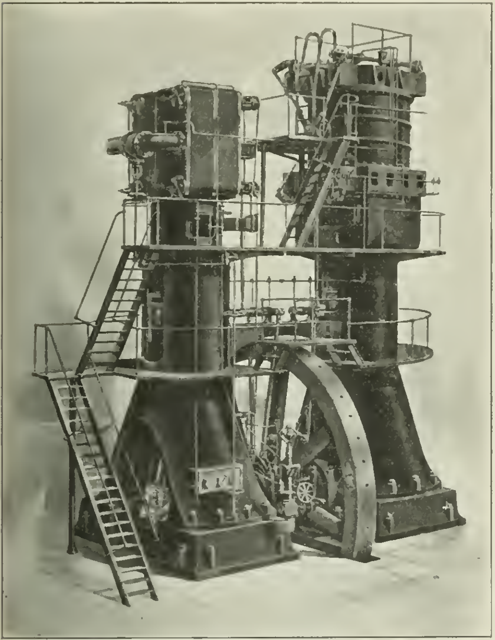


FIG. 21.—VERTICAL QUARTER CRANK BLOWING ENGINE, 42-IN. STEAM, 84 AIR X 60 STROKE

This can, in my judgment, mean in the long run only one thing, high maintenance and repair cost, which, coupled to the high first cost of this type of engine with the consequent high fixed charges, all tend to make this an undesirable type from the technical, operating and financial points of view.

### THE HORIZONTAL VERTICAL

The horizontal vertical, shown in Fig. 22, presents almost the same conditions, though these are offset by the fact that the running balance of these engines, if properly made, is excellent, and, therefore, their steadiness on their foundations very great. On the other hand, the horizontal vertical requires as much height and much greater foundation than the quarter crank vertical.

Many years ago the late P. L. Weimer, realizing that the energy of the steam was mainly developed in the early part of the stroke, and absorbed by the air mainly in the latter part of its stroke, built what are now known as horizontal vertical engines, with horizontal steam cylinders and vertical air cylinders, both working on the same crank pin. With this arrangement the earlier part of the steam stroke obviously takes place during the latter part of the air stroke. Consequently, a certain equalization of the work absorbed and expended from instant to instant is made, which justified in part the use of this type when speeds were low and inertia effects negligible.

In later years these engines have been built by other builders in very large sizes, and are favorably considered by some operators, although the inertia effect with moderate speeds makes this design wholly unnecessary. In these engines, also, it is obvious that the total work generated in the steam cylinder must be transmitted to the crank pin with a friction loss of some 10 per cent. and then transmitted back from the crank pin through another set of running parts to the air cylinder. It is reasonable to assume that here also there is a loss in friction of 10 per cent., making the mechanical efficiency of this engine, also as a whole, only about 81 per cent.

I have unfortunately no figures giving the mechanical efficiency of these engines in service, but there is no reason to expect that it is much higher than the figure given. On the other hand, with the direct connected steam and air pistons of the horizontal tandem and a proper proportioning of the cylinder diameters, speed, etc., it is obvious that only about 20 or 25 per cent. of the total energy need be transmitted through the running parts, and that the friction of the engine accordingly should be only 6 or 7 per cent. instead of 19, as in the other case.

In confirmation of this, which may seem an extreme statement, tests have been made of Nordberg compressors designed to make use of this principle, which had a mechanical efficiency of 95 per cent. at full load.

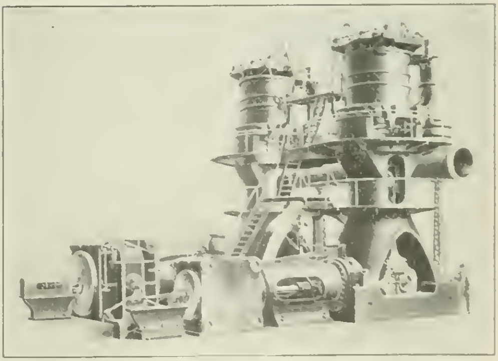


FIG. 22.—HORIZONTAL VERTICAL CROSS-COMPOUND, 52-IN. AND 90-IN STEAM, 90-IN. AND 90-IN. AIR X 60 STROKE BLOWING ENGINE CO., THE WM. TOD CO.

There is, however, one feature of the horizontal vertical engine which deserves attention. It is evident from what we have said above that the inertia of the reciprocating parts can be utilized to reduce the stresses in the running parts very greatly. Nevertheless the inertia stresses due to these heavy parts which move at high velocities alternately in opposite directions exist in the machine as a whole and tend to shift it back and forth on its foundation in the case of the horizontal engine without counterweight, or to pull the crank shaft up and down with an equal force if full counterweight be used, these conditions being reversed in the case of the vertical engine. But when two sets of reciprocating parts at right angles work on the same crank, the inertia effect of one set in horizontal and that of the other in vertical, these components are combined into a single constant stress in a direction exactly opposite to that of the crank, so that by counterweighting completely one set of the reciprocating parts, the horizontal-vertical engine runs in almost perfect balance.

Where foundations are bad and engines must be set upon piles driven through mud to the bedrock these considerations are of much importance, and this type of engine is the best adapted of any to prevent serious shaking of the engine and its foundation or even the whole surrounding country for a distance of many hundred feet, as has happened at one large plant where the blowing engines were supported on piles.

### THE LONG CROSS-HEAD TYPE

This engine requires small foundation and small space for a unit of given size, the vertical height required being about the same as that of any other type of engine with reciprocating parts in the vertical plane except the vertical tandem, or steeple type, which is much higher. The stresses are, of course, transmitted with great directness in these engines from one piston to the other, and through rigid parts, but there is a prejudice on the part of some engine builders against running these engines at a speed which would bring the inertia effect of their reciprocating parts up to the best point for smooth running and low wear. The exact reason for this disinclination I have never been able to discover, and it is only fair to state that it does not hold with all builders, some of whom build engines of this type to run up to seventy or seventy-five revolutions.

There is no doubt that when run at proper speeds and when built sufficiently strong to withstand vibration, this is a useful, reasonably inexpensive and satisfactory type of engine, capable of giving reliable service for long periods at a stretch, such as are needed in blast-furnace work.

It is, of course, open to the objection which exists with all vertical engines, that supervision, inspection and repairs are much more difficult and expensive than they are with horizontal ones.

### THE STEEPLE TYPE OR VERTICAL TANDEM CROSS-COMPOUND

A design of this type of engine built by the Southwark Machine Company is shown in Fig. 23, while nearly all of the prominent builders build this type of engine on demand, the design of valve gear, etc., being different with the different builders, but the general type of construction being the same.

The great objection to this type of engine is its great height with the consequent difficulty of securing adequate inspection and care, and its liability to vibration owing to its height and the elasticity of its small base. It will be seen in the illustration that there are four platforms above the main floor, all of which must be frequently visited for adequate inspection and care of the engine.

It is not to be denied either that these engines are exceedingly difficult of repair. Even where a crane is available, as it should always be in a modern blowing-engine house, there are many parts which it is impossible to reach with the crane without great difficulty, so that this virtually involves partly dismounting the engine for certain repairs. With the limited room available for this work on the platforms it can only be done at a disadvantage, and as a consequence repairs on engines of this type are more difficult, slower, and more expensive than they are on a horizontal engine of the same size.

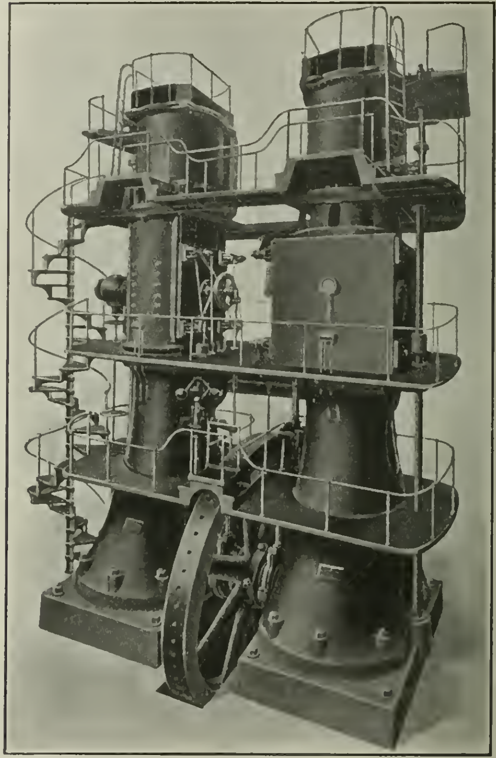


FIG. 23.—SOUTHWARK STEEPLE BLOWING ENGINE QUARTER CRANK COMPOUND

In regard to speed, the engine stands on a relatively small foundation and with its great height excessive vibration is likely to be set up even at very moderate speeds, and this type of engine therefore cannot in general obtain those advantages of high speed which are available to some other types, with consequent loss of

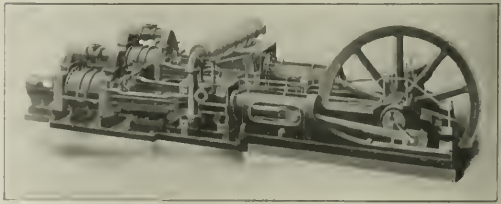


FIG. 24.—HORIZONTAL CROSS-COMPOUND BLOWING ENGINE, 44 AND 84 STEAM, 90-IN. AND 90-IN. AIR X 72 STROKE. THE WM. TOD CO., YOUNGSTOWN, OHIO.

efficiency from not having the most desirable resultant diagram of steam, air, and inertia pressures.

### THE HORIZONTAL CROSS-COMPOUND WITH TANDEM AIR CYLINDERS

This type of engine, shown by Figs. 24 and 25, is open to the disadvantage that it requires the largest and most expensive foundation of any steam blowing engine, and that it requires also a great area of building and ground, leading to high cost on this account, but the building cost as a whole is not so excessive as might be expected because of the very moderate height required with this engine, so that only a relatively low building is needed for its accommodation.

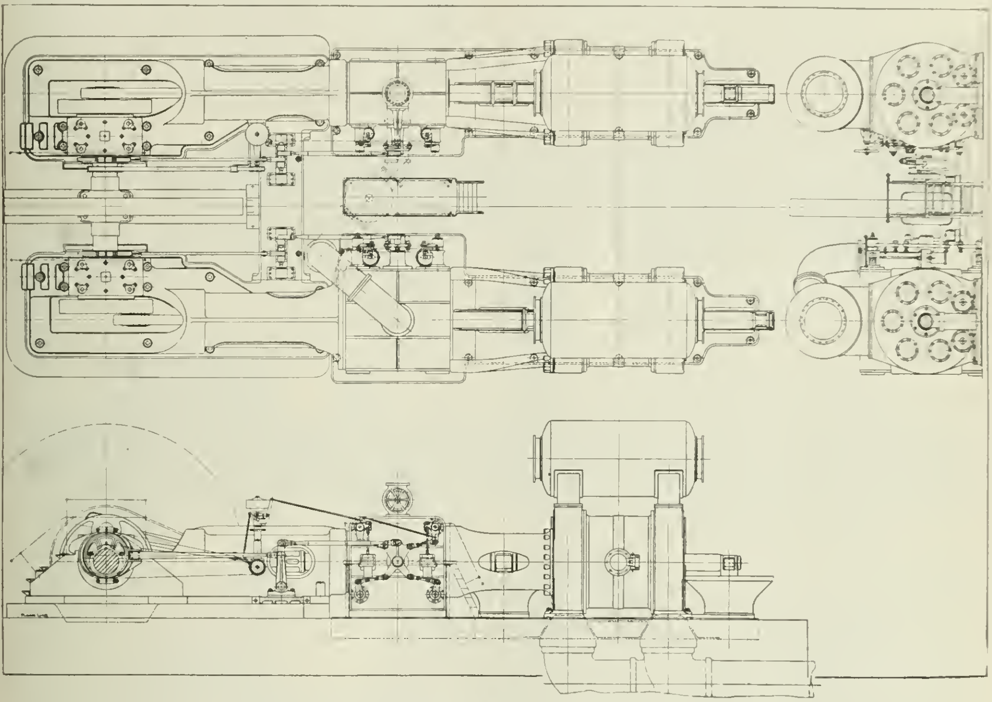


FIG. 25.—"MESTA" CROSS-COMPOUND STEAM BLOWING ENGINE

Its great foundation also acts as a great anvil to absorb inertia stresses and unbalanced centrifugal effects of counterbalance, which tend to cut down to a minimum the possible vibration of the unit as a whole.

Owing to these considerations the engine is capable of being run at the speed best adapted to produce the highest economy and this higher speed of unit permissible as compared with most other types of engines goes far to offset any disadvantages in total first cost under which a unit of a given size of this type labors as compared with that of some other types. The whole of the engine is down on or near the ground level, and I believe that operators who have had experience will bear me out in saying that one attendant will look after two engines of this type more effectively than two attendants can after one of the steeple type of the same size.

This engine has, of course, the desirable feature of transmitting the stress from one cylinder to another through rigid members and not through moving joints, and in consequence it is capable of realizing the benefits of this system to the maximum.

Through the kindness of Mr. E. T. Child, of the Southwark Machine Company, I am able to reproduce in Fig. 26 a set of steam and air cards, one of a large number of sets taken by him personally from an engine of this type, running at a proper speed, in which the efficiency for the average of the whole set was about 91 or 92 per cent. This was in actual operation, no particular attempt being made to obtain a record, and I have no doubt that other well-designed engines of this type would do as well, if run at the proper speed.

One of the essential features in the design of the modern horizontal cross-compounds is the means for relieving the bottom of the cylinders of the drag of the heavy pistons necessary in large units. This is accomplished by putting a cross-head and slide at each end of each of these large cylinders and making the piston

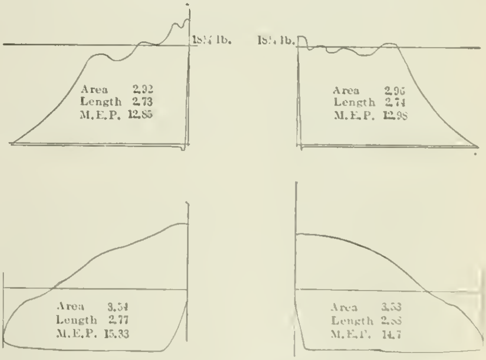


FIG. 26—MECHANICAL EFFICIENCY 92 PER CENT

rods strong enough to carry the pistons clear of the cylinder, so that nothing but the packing ring touches the wall of the cylinder.

In some cases the piston rods are made of high-grade steel and cambered upward before use to the amount by which the weight of the piston will deflect them so that they are perfectly straight in service.

Mr. Nordberg has gone still further and uses a hollow cast-iron trunk of large diameter whose only function is to carry the weight of the piston and take compression stresses, the tension stresses all being taken by a much smaller steel rod through the center.

The type shown is built as a cross-compound steam engine and this type of construction is also much used in gas engines. It has many of the advantages of the horizontal tandem engines but the simplicity and accessibility of the running gear due to the stretcher rods from one cross-head to the other are not so great as in the straight tandem type, and I have never known what advantages this engine possessed to offset these disadvantages unless it be the accessibility of the cylinders due to the elimination of the tandem arrangement. It is a type of engine approved by engine builders very generally, and is recommended by them for high speeds.

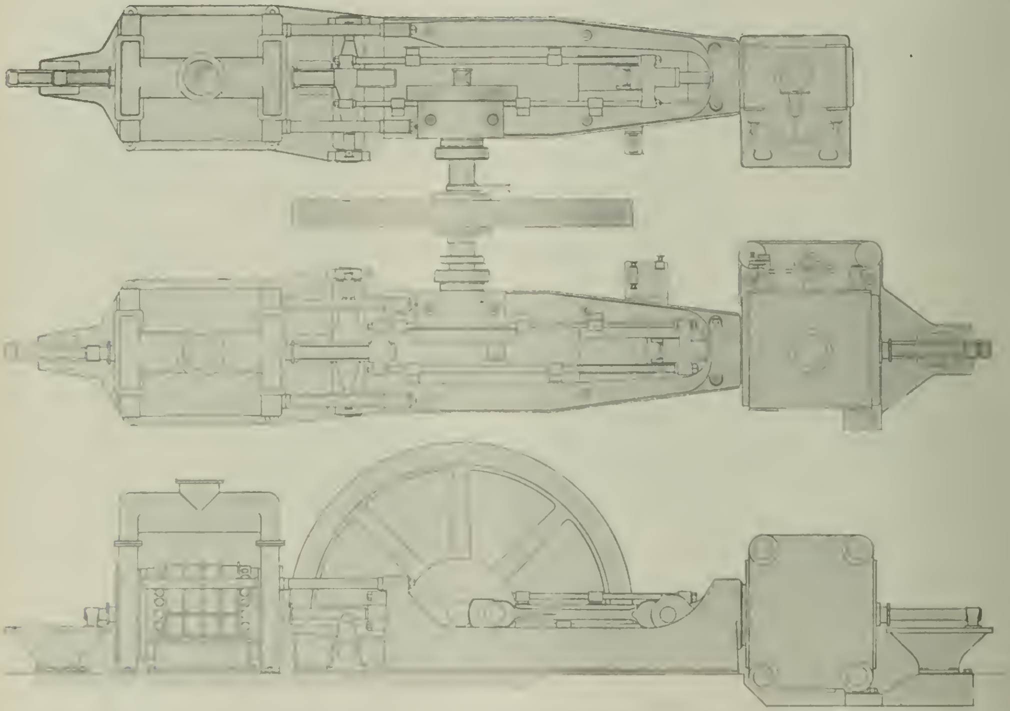


FIG. 27—INSIDE-CRANK BLOWING ENGINE SLICK AIR CYLINDERS 36 IN. AND 72 IN. X 54 IN. STEAM, 72 IN. AND 72 IN. X 54 IN. AIR. ALLIS-CHALMERS COMPANY

This design not only frees the engine from a very heavy friction load, but also relieves the cylinders from wear and puts them on a parity in that respect with vertical cylinders.

### THE INSIDE-CRANK ENGINE

The inside-crank type of engine is shown in Fig. 27.

The crankshaft lies between the two cylinders and the piston rod instead of passing directly from one cylinder to the other; is divided into two parallel rods symmetrically placed with reference to the axis of the cylinders, and in a plane about 45 deg. from the horizontal.

These two parallel rods take hold of suitable projections which are provided on the cross-heads for each cylinder.

This arrangement makes an uninterrupted open space in the axis of the engine and between the two cylinders in this uninterrupted open space the connecting rod and crank work.

The **Foxboro Company**, recently organized under the laws of the Commonwealth of Massachusetts, has taken over all assets and liabilities of The Industrial Instrument Company of Connecticut, which was a holding company, and of The Standard Gauge Manufacturing Company of Connecticut, with factory at Foxboro, Massachusetts. The Foxboro Company manufactures the rapidly growing line of Foxboro improved recording gauges, thermometers, tachometers and pyrometers which are sold by the Industrial Instrument Company having main office at Foxboro, with branch offices at New York, Chicago, St. Louis, San Francisco, and Birmingham. The Foxboro Company owns all of the capital stock of The Industrial Instrument Company. Mr. Edgar H. Bristol and Mr. Bennet B. Bristol continue as president and treasurer respectively of The Foxboro Company. In fact, there are no changes in the personnel or policies of the companies, the above changes being made to concentrate and simplify the organization.

# Concentration of Complex Sulphide Ore from the Mary Murphy Mine[1]

BY GEORGE E. COLLINS

Nothing can be farther from the truth than the common idea that a scheme of ore-treatment can be finally worked out in all its details prior to construction of a milling plant; or that such a scheme, once fixed, should need no reconsideration during the life of the mine it has to serve. This presupposes a homogeneous ore-deposit, unchanged scale and methods of working, and an amount of time and completeness of facilities for testing which are rarely available in practice.

In actual experience, uniform ore-bodies are uncommon. Perhaps the large low-grade dissemination and replacement ore-bodies approach nearest to uniformity; and even these appear so, largely because they are worked on so great a scale that their mineralogical and physical differences are averaged. And while, in the case of some of these large low-grade mines, great sums were spent in testing and on experimental plants before the serious work of construction was commenced, nothing is more certain than that radical changes are yet possible. It is therefore no reflection on the skill of the metallurgist or the thoroughness of his preliminary work, if he finds it necessary to continue testing throughout the life of the plant.

Constant testing is necessary, not merely to indicate ways in which the metallurgical saving of a plant may be improved, but also to control the working costs, and the relation of metallurgical to commercial saving. Furthermore, when the most suitable practice has been established, it is necessary to repeat similar tests at intervals, so as to ensure that no changed factor has crept into the practice, unknown to the management. Even apart from all these, there is a duty incumbent on every engineer to investigate the reasons for what he is doing and the results achieved by it; and last of all, the possibility that by constant study and record of his own results he may add to the general stock of knowledge, by the aid of which he may assist his fellows in solving similar problems more expeditiously.

### Discordant Results Obtained in Testing

I do not know whether engineers experience as much difficulty as I do in obtaining concordant results from their testing work. If so, they do not mention it in their published results. Having had the painful privilege in some cases of "cleaning up" after some of my confrères, I incline to suspect that the difference is sometimes one of puzzling out the discordant results on the one hand, and covering them up on the other.

There are innumerable chances for results to go wrong, either in the preparation of the samples, or in the assay office itself. I suppose that by the exercise of infinite care such discrepancies might be avoided, but so far I have not found any way of discovering or educating infallible men. Both from the point of view of general efficiency of staff and that of effective control of operation, I prefer to get a large amount of work through, and a large number of screen analyses and other tests made, even at the risk of having some inconsistent results included in the reports. Even with this, the tendency is to delay the completion of tests until they have become old history, and have to a large extent lost their value for the guidance of everyday operation.

I suppose everybody has had much the same experience; but it may be worth while, in order to illustrate the difficulties that crop up in this class of work, to give one example:

TABLE I—SCREEN ANALYSIS

4 Ft. Hardinge Mill — Re-Grinding Jig Middling

*Elevation* from feed to discharge end, 1¼". *Speed* 30 R.P.M.
*Solids* = 18.7% = 22.63 tons ore per 24 hours.
*Water* = 81.3% = 120.00 tons water per 24 hours.
Total tonnage 142.63 tons per 24 hours.

| FEED | | | | | | | DISCHARGE | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample No. | Mesh | % | Oz. per Ton Au. | Oz. per Ton Ag. | Percentage Pb. | Percentage Zn. | Sample No. | Mesh | % | Oz. per Ton Au. | Oz. per Ton Ag. | Percentage Pb. | Percentage Zn. |
| D-1.... | + 20 | 46.34 | .60 | 5.2 | 17.2 | 33.6 | ... | + 20 | | | | | |
| 2..... | + 40 | 12.20 | .64 | 5.7 | 16.0 | 32.4 | DD-0. | + 40 | | | | | |
| 3..... | + 60 | 7.32 | .36 | 4.5 | 18.7 | 22.8 | 1. | + 60 | 2.44 | * | * | 7.5 | 23.2 |
| 4..... | +120 | 8.54 | .32 | 4.3 | 8.2 | 17.6 | 2. | +100 | 12.19 | 1.00 | 9.0 | 5.7 | 22.5 |
| 5..... | +200 | 14.63 | .26 | 6.0 | 9.8 | 15.0 | 3 | +200 | 34.15 | 1.24 | 5.4 | 11.0 | 26.5 |
| 6..... | −200 | 10.87 | .28 | 6.0 | 16.5 | 12.3 | 4 | −201 | 51.22 | .58 | 6.8 | 8.8 | 24.3 |
| Average assay (calculated)......... | | | .48 | 5.3 | 15.2 | 26.2 | Average assay (calculated)...... | | | .92 | 6.6 | 9.1 | 24.8 |

*Not enough for assay.

PERCENTAGES OF TOTAL CONTENTS IN VARIOUS SIZED PRODUCTS

| Mesh | *Au.* | *Ag.* | *Pb.* | *Zn.* | Mesh | *Au.* | *Ag.* | *Pb.* | *Zn.* |
|---|---|---|---|---|---|---|---|---|---|
| + 20 | 58.1 | 45.1 | 52.3 | 59.3 | .... | ..... | ..... | ... | .. |
| + 40 | 16.3 | 13.0 | 12.8 | 15.1 | + 40 | .... | ..... | ... | .. |
| + 60 | 5.5 | 6.2 | 9.0 | 6.4 | + 60 | ..... | | 2.0 | 2.3 |
| +100 | 5.7 | 6.9 | 4.6 | 5.7 | +100 | 13.6 | 17.1 | 7.6 | 11.1 |
| +200 | 7.9 | 16.4 | 9.4 | 8.4 | +200 | 47.4 | 28.7 | 41.1 | 36.5 |
| −200 | 6.4 | 12.3 | 11.9 | 5.1 | −200 | 38.9 | 54.2 | 49.3 | 50.1 |

Here it will be observed that in the process of crushing, according to the screen analyses, the gold has been raised from 0.48 oz. to 0.92 oz. per ton, and the lead has dropped from 15.25 per cent. to 9.14 per cent.

There is nothing exceptional about the former; we have found that gold tends to accumulate in tube-mills, jig-beds, elevator sumps, etc.—in fact, everywhere in the plant where there is any opportunity for extreme classification to take place, and for exceptionally heavy particles to lodge. I shall return to this subject later.

The changes in the lead percentage are less to be expected *a priori*. But it illustrates the fact that the Hardinge mill (or other tube-mill) is a natural classifier, in which the heavier particles are retained longer, and ground finer, than the relatively lighter particles. As in this plant we always run a machine two shifts or more after making any change before taking samples, this should not lead to discordant results, if the feed were uniform. Uniformity of feed, however, is a most difficult thing to secure, when you have a mine yielding excessively variable ores, and a mill of moderate or small capacity. In this case we have a storage, with some natural mixing in the crushed-ore bins, of over five days' mill capacity; or an average of say two and one-half days' ore always on hand; yet uniformity of feed is an ideal which we have never attained.

Any change in grade or fineness, occurring within a couple of hours of the time when a test is being made, takes several hours before the discharge and feed are equalized; and meantime other changes may have occurred. In order to obtain concordant results from feed and discharge, therefore, it is desirable to continue a test for a week or more, samples of feed and discharge being taken at regular intervals throughout. As we cannot always wait so long for results or tie up a machine so long for purely experimental purposes, it is sometimes necessary to put up with results which we know beforehand may be incorrect, in some direction.

---

[1] Excerpt from the author's presidential address before the Colorado Scientific Society, entitled "Systematic Testing in the Evolution of Mill Practice." The portion here given has reference to the Mary Murphy mill, and affords interesting supplementary data to a descriptive article on the same mill, published in our issue for January, 1914, and to Mr. Dyke V. Keedy's discussion of that article in our issue for March, 1914.

The variations in assay serve as an index to probable corresponding variations in sizing. The sulphide minerals being so much softer than the gangue, it is certain that if there are unequal proportions of mineral in the feed and discharge, there will be corresponding variations in the proportions in the sizing, apart from those normally due to the work performed in the mill.

A similar discrepancy was observed in assays of feed and discharge from a 4-foot Hardinge mill which we used experimentally for regrinding coarse sand tailing, with a view to its treatment on carpets and plates. This operation yielded a small quantity of amalgam, and some carpet washings assaying 2.75 ounces of gold per ton. Yet, during a period of several weeks, the daily samples of heads and tails showed, with I believe only two exceptions, a slightly higher gold content in the latter than in the former. The explanation, in this instance, must be that minute particles of gold and amalgam had lodged in the interstices of the silex lining, and collected in the enriched sands left in the mill before the test commenced, and gradually worked their way out in admixture with the pulp. Had we foreseen this difficulty, we might have avoided it by deferring this test until the mill had been newly lined, and then started it up with a new load of pebbles. We, however, supposed, not unnaturally, that as we intended continuing this test for a considerable period of time, any irregularities of the kind indicated would naturally adjust themselves after running a day or two.

### Conical and Cylindrical Tube Mills

It follows from the foregoing, I think, that no crushing appliance in which, as in the Hardinge and ordinary cylindrical tube-mill, classification takes place, can ever be a perfect non-sliming fine grinder.

The conical end of the Hardinge mill acts, to some extent, as a device to expedite continuous discharge, in much the same way as the device recently brought out by Chalmers and Williams for improving the discharge from a cylindrical tube-mill. The latter, which consists of a perforated diaphragm, between which and the discharge end is a series of adjustable shelves intended to raise the pulp to the center where it can flow out, may be more effective, but has not yet been tried out sufficiently to prove its value. The conical end of the Hardinge, while of limited efficiency, is simple and positive, and really works. One can obtain nearly as small a proportion of slime in a long tube-mill as in a Hardinge, by crowding the feed and using a large quantity of water; but apparently there is then a slight tendency for the discharge to contain still more oversize.

Mr. Hardinge's original contention that with his mill the weight of blow is automatically adjusted to suit the progressively finer particles of pulp as they pass from head to discharge end, and that owing to this automatic adjustment there is practically no necessity for return of oversize, is, according to our experience, not borne out by the facts. As in the case of the tube-mill, if you crowd the tonnage and increase the water sufficiently to obtain a granular product you have to arrange for the return of a very considerable amount of oversize.

In various publications Hardinge has illustrated this supposed zonal action in his mill by cuts in which he superimposes on a picture of the conical mill, an outline of several gravity stamps, commencing with one of heavy weight and high drop, and progressively lessening to one of small weight and low drop at the end; the stamps being supposed to represent the force of blow struck by the pebbles in the corresponding stages of the Hardinge mill as you pass from feed to discharge end.

This is, however, largely a fallacy. It is true that the size of pebbles is automatically graded, to some extent, and obviously the force of blow struck would be thereby lessened. But the peripheral speed is at the same time lessened to such a degree that near the discharge end the pebbles merely slide on one another without cascading, so that there is no crushing action worth mentioning, and what actually occurs is a slight process of abrasion, which is just what we want to avoid. In fact, in comparing the work of the Hardinge with that of the tube-mill, according to our experience, it is pretty much a question of relative first cost and operating expense. We have at Romley one 3½-foot by 16-foot Gates tube-mill, two 6-foot by 22-inch Hardinge mills, and one 4-foot by 22-inch Hardinge. We find that the capacity of the tube-mill and that of one 6-foot Hardinge, using the same feed, are almost identical; and the cost of the Hardinge was about 20 per cent. greater. As to power consumption, we have no means of measuring. The Hardinge uses more pebbles, and has to be relined oftener.

### Separate Regrinding of Sand Tailing and Mineralized Middling

In the Mary Murphy mill, we have hitherto used the 6-foot Hardinges and the tube-mill to do the same work on the same feed. As the result of our experiments, we expect hereafter to do the bulk of the regrinding with the Hardinges, using the tube-mill to regrind the coarse sands from the tables. The 4-foot Hardinge was intended, and is still used, to grind the heavily mineralized middling from jigs, the idea being that this material required for proper granulation a lighter pebble and less total weight of pebbles; furthermore, that it should be more satisfactorily ground by itself, unmixed with the particles of hard, tough quartz and rhodonite of the gangue. I now doubt very much if this latter hypothesis was correct; and incline to suspect that one effect of the hard gangue particles may be to protect the soft grains of mineral, in some degree, from sliming after they have once been crushed fine enough. What, however, is certain is that crushing the jig-middling in a separate machine enables us to realize precisely what result we are actually obtaining. This is indicated by the color of the discharge, which looks a good deal like ink, and by the screen analyses, which show anywhere from 30 to 70 per cent. of —200 size, averaging in metallic contents 65 per cent. of the lead and 51 per cent. of the total zinc.

The sizes below 100-mesh contain nearly all the lead and most of the zinc in the feed (93 per cent. of the total lead and 85 per cent. of the total zinc).

As stated above, by greatly crowding the feed we are able to lessen the proportion of unduly ground material, to a very large extent. This is well shown by the screen analysis (Table II) which shows only 12.1 per cent. of —200-mesh material.

The use of this method is, however, not always possible; for in a small plant, or even one of moderate size, the tonnage available of any given material is limited, and is fixed by the relation between various factors due to other machines; and by no means always corresponds with the sizes of machines commercially manufactured. And this again is a decided disadvantage, for small plants, of the entire tube-mill class of machine, in which the character of the product as well as the cost of operation is modified by the quantity of feed.

Moreover, in the example shown, the lessened quantity of undersize is obtained at the expense of producing a prohibitive proportion of oversize (49.3 per cent.).

To show the enormous influence on product of differing quantities of feed, the character remaining similar, I reproduce screen analysis (Table III) which shows that by reducing the feed to 14 tons, keeping the other factors approximately constant, the result was entire elimination of oversize, but the increase of —200-mesh product to the enormous figure of 72.8 per cent.

TABLE II—SCREEN ANALYSIS

4 Ft. Hardinge Mill. Re-Grinding Jig Middling

*Elevation* from feed to discharge end 1¼". *Speed* 28 R.P.M.

*Solids*=32.4%= 34.6 tons per 24 hours.

*Water*=67.6%= 72.0 tons per 24 hours.

Total tonnage 106.6 tons per 24 hours.

*Pebble Load*, 0.9 tons. Main mill treating 140 tons per 24 hours at the time when samples were taken

| FEED | | | | | | DISCHARGE | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Mesh | % | *Au.* | *Ag.* | *Pb.* | *Zn.* | Mesh | % | *Au.* | *Ag.* | *Pb.* | *Zn.* |
| On 10 | 32.6 | .12 | 2.1 | 6.8 | 11.0 | On 10 | 3.0 | .22 | 2.9 | 4.4 | 9.5 |
| " 14 | 17.0 | .30 | 1.9 | 4.7 | 11.3 | " 14 | 4.2 | .18 | 2.4 | 4.4 | 10.0 |
| " 20 | 14.5 | .18 | 2.0 | 4.1 | 10.1 | " 20 | 7.2 | 1.24 | 2.3 | 3.8 | 9.4 |
| " 28 | 11.6 | .21 | 2.3 | 4.1 | 10.3 | " 28 | 10.2 | .56 | 2.2 | 3.5 | 9.2 |
| " 35 | 8.3 | .14 | 2.3 | 4.4 | 10.7 | " 35 | 12.1 | .42 | 2.1 | 3.5 | 9.0 |
| " 48 | 4.7 | .11 | 1.9 | 3.1 | 11.3 | " 48 | 12.6 | .42 | 2.6 | 3.8 | 10.6 |
| " 65 | 3.1 | .14 | 2.2 | 2.5 | 12.7 | " 65 | 11.1 | .44 | 2.9 | 6.3 | 14.1 |
| " 100 | 2.9 | .12 | 1.8 | 2.3 | 11.7 | " 100 | 10.7 | .44 | 3.2 | 7.4 | 15.5 |
| " 150 | 2.4 | .09 | 1.7 | 1.7 | 10.0 | " 150 | 9.6 | .40 | 2.9 | 9.6 | 16.1 |
| " 200 | 1.1 | .08 | 2.0 | 2.5 | 11.7 | " 200 | 7.2 | .21 | 3.7 | 13.4 | 15.1 |
| thru 200 | 1.8 | .12 | 3.9 | 8.9 | 13.0 | thru 200 | 12.1 | .18 | 4.4 | 15.2 | 12.5 |
| Calculated average assay | | .15 | 2.1 | 5.0 | 10.9 | Calculated average assay | | .44 | 2.9 | 7.1 | 12.1 |

(Tyler standard testing screens used in above test.)

TABLE III—SCREEN ANALYSIS

4 Ft. Hardinge Mill. Re-Grinding Jig Middling

*Elevation* from feed to discharge end 1¼". *Speed* 28 R.P.M.

*Solids*=35%=14.04 tons per 24 hours.

*Water*=65%=26.07 tons per 24 hours.

Total tonnage 40.11 tons per 24 hours.

Mill running two shifts before samples were taken

*Pebble Load*, 0.8 tons. Selex lining. Main mill treating 150 tons per 24 hours at the time when samples were taken

| FEED | | | | | | DISCHARGE | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Mesh | % | *Au.* | *Ag.* | *Pb.* | *Zn.* | Mesh | % | *Au.* | *Ag.* | *Pb.* | *Zn.* |
| On 10 | 66.0 | .40 | 6.4 | 22.0 | 23.5 | On 10 | . | . . | .... | .... | .... |
| " 14 | 16.0 | .22 | 7.6 | 16.2 | 22.8 | " 14 | . | . | .... | .... | .... |
| " 20 | 9.9 | .26 | 5.1 | 16.2 | 21.7 | " 20 | | . | .... | .... | .... |
| " 28 | 4.2 | .34 | 5.9 | 19.0 | 19.0 | " 28 | . | . | .... | .... | .... |
| " 35 | | Not enough for assay | | | | " 35 | . . . | . . | .... | .... | .... |
| " 48 | . | | | | | " 48 | | | | | |
| " 65 | 2.0 | Combined with 100 mesh | | | | " 65 | 4.5 | 2.80 | 7.4 | 6.8 | 14.6 |
| " 100 | 1.9 | .38 | 5.4 | 19.0 | 14.0 | " 100 | | | | | |
| " 150 | ... | | ... | .... | .... | " 150 | 9.1 | 1.62 | 5.2 | 11.6 | 17.4 |
| " 200 | .. | | .. | . . | .. | " 200 | 13.6 | .82 | 5.7 | 21.2 | 17.3 |
| thru 200 | | | ... | . . | . . | thru 200 | 72.8 | .32 | 6.5 | 32.2 | 14.0 |
| Calculated average assay | | .35 | 6.4 | 20.2 | 22.6 | Calculated average assay | | .62 | 6.3 | 27.7 | 14.8 |

Percentages of Total Contents in Various Sized Products

| FEED | | | | | DISCHARGE | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Mesh | *Au.* | *Ag.* | *Pb.* | *Zn.* | Mesh | *Au.* | *Ag.* | *Pb.* | *Zn.* |
| +10.... | 74.6 | 66.0 | 71.6 | 68.5 | +48 to +100 | 20.4 | 5.3 | 1.1 | 4.4 |
| +11.... | 9.9 | 19.0 | 12.8 | 16.1 | +150 | 23.6 | 7.5 | 3.8 | 10.7 |
| +20... | 7.3 | 7.9 | 7.9 | 9.5 | +200 | 18.0 | 12.3 | 10.4 | 15.9 |
| +28..... | 5.0 | 3.8 | 4.0 | 3.5 | −200 | 37.7 | 75.0 | 84.7 | 68.9 |
| +35 and below | 4.2 | 3.3 | 3.7 | 2.4 | | | | | |
| | 100.0 | | | | | | | | |

Screen analysis (2) also illustrates in a rather striking way the tendency for the total gold in discharge to exceed that in the feed. There were 11 screen sizes in each case, and in all but one size, when feed and discharge ran about the same, the gold was far higher in the discharge. The average gold indicated by the assays in the feed was 0.15 ounce, and in the discharge 0.44 ounce. Substituting for the highest assay in the discharge the average of the assays on the adjacent sizes, the average of the discharge is reduced to 0.37 ounce, or two and one-half times the average of the feed.

We are now installing a pair of rolls, to be set close, to recrush these soft middlings, and shall hold the 4-foot Hardinge in reserve, for use when some of the other machines are out of commission for repairs.

### Value of Screen Analyses

I have always been disinclined to attach overmuch weight to the details of screen analyses, excepting as to their general trend. If we take two identical samples, and compare duplicate screen analyses on them, made by different individuals, or even by the same person, we usually find wide variations in the results. Such differences indeed we may expect, in view of the rectangular apertures employed, and the varied forms of the particles to be screened. When a particle is, in every section but one, larger than the screen aperture, and in that one section just small enough to pass through the aperture, but only if rightly oriented, it is clear that particle and aperture may be brought into contact perhaps a hundred times before it will pass, and in the meantime sharp edges of many other particles, which at first would not have passed through, may have become worn down sufficiently to enable them to pass.

The difference between screen analyses performed wet and dry is well known.

Some of the spotty gold assays which have crept into our screen analyses may perhaps be due to the alternate use, for such tests, on rich and poor material, of the same nests of screens. In the finer sizes, a considerable proportion of the apertures becomes blinded, and if there are small particles of gold included in the material thus held in the screen, they may become dislodged when screening subsequent samples, so introducing erratic assays into the latter. As far as possible, however, we guard against this contingency by using a different set of testing screens for high-grade and low-grade mill work.

I referred above to occurrences of free coarse gold in the mill. So far as I can learn, during the entire 30 years of the mine's history, no specimen showing free gold has ever been seen. Yet the existence of pockets of free gold has been inferred from the occasional erratic bunches of extremely rich ore encountered, and the unusually spotty assays, which suggested that the rich ore could not exist in the form of telluride or other friable material.

At intervals, in the mill, we have found sudden evidences of coarse gold. The gold ordinarily caught on the plates is fine; by dissolving the amalgam with nitric acid, 82 per cent. was found to pass a 100-mesh screen. Its fineness, moreover, averages only 550. The other kind of gold is of about 650 fineness, and coarse—nearly all of it over 20-mesh. It is mostly caught on the carpets used below the plates, and on the first few riffles of the Card tables which are fed from the two first spigots of the classified line. Both these products are taken direct in pipes to a grinding pan of arastra type, with a bottom paved with silex bricks, and a stone drag, where they are ground continuously with quicksilver; the amalgam being cleaned out daily through a spout in the bottom, and the overflow settled and added to the high-grade concentrate. In this way we avoid difficulty in sampling and selling unnecessarily spotty concentrates, and furthermore are able to keep slightly better control of the gold contents throughout the system.

At times on the jig-beds, we have been able to sort out quite a number of pounds of metallic particles, attached sometimes to quartz and sulphide minerals.

These range in size from 2 mm.—the mesh of the jig-screens used—up to 1/3 inch. One or two such nuggets have been found in the trommels over ½ inch in diameter, nearly all of gold of about 670 fineness.

### Methods of Calculating Recovery

There has been a great deal of discussion in the technical press during the past year with reference to methods of calculating rates of extraction in mill work. We have the partisans of the method of calculating from weights and assays of tailing, or from assays entirely, excluding weights, together with products, on one hand, and on the other hand, those who insist on the necessity for sampling heads, which usually requires a sampling plant. To me it seems a question to be decided on the merits of each individual case. Poor samples of mill feed are worth very little; and accurate sampling usually adds materially to costs of construction and operation. Samples of tailing can usually be obtained with relative accuracy; and products must be accurately sampled for purposes of sale, so that their accurate determination is chargeable, not to cost of mill operation, but to cost of realizing products. Where only one or two products are to be marketed, it seems to me that the method of calculating heads is admissible; the objection to its use comes with more validity from the general management, which may require the independent check on the mine work which is afforded by actual sampling of the mill heads.

Where on the other hand we have many metals to be recovered, and many products to be made, which are marketed at irregular intervals, samples of headings become almost indispensable in order to control the daily work. Even with this help, in the case of the plant which I have in mind, the locked-up material in sumps, mills, etc., so affects the daily tailings that (especially as to gold content) it does not always correspond with the daily feed. This is strikingly illustrated by the fact that, when we have a daily feed which happens to run up in gold, the tailing often shows no increase; but it does so for several days thereafter.

In the course of the discussion above referred to, Mr. W. S. Welton objected to the use of tailing assays in figuring savings, for the reason that the water decanted from the tailing sample "invariably contains higher values than the material which settles and accordingly carries away a large percentage in suspension." To quote from his article in the *Engineering and Mining Journal* of July 12, 1913: "Under working conditions, it is impossible to ascertain directly the real value of the tailing.

"From the moment concentration commences, the water made use of carries off mineral of value, and this continues all through the process. The amount of floating mineral will vary with the fineness of division of the particles, degree of concentration, amount of water used, and inclination of the tables, or with the rapidity of concentration. The effect of these circumstances is to cause the settled tailing to be invariably of lower assay value than if there was no float."

A little further on Mr. Welton states that "to estimate the extraction" it is "clearly necessary to know either the correct value of the mill feed or of the tailing," and in view of the difficulty he considers to exist in sampling the tailing recommends dependence on sampling the feed.

This contention was supported by a number of assays taken in the course of some concentration tests on silver ores. It would, however, be difficult to find a more striking case of the fallacies which may result when one argues from the particular case to the general. In the first place, while the suspended slime tailing from concentration is usually of higher assay than the sand, it is not "invariably" or necessarily so—in my own experience I have found several instances where the contrary was true. In the second place, if proper time is allowed for settling, and lime or other aid to settling made use of, the loss in suspension is usually small. Finally, as the ease of taking correct samples increases with the fineness of the particles, there is no excuse for not getting accurate samples of the water, plus whatever matter it may hold in suspension; nor is there any insuperable difficulty in evaporating the entire sample to dryness, water and all. What we do in practice is to settle the sample with lime, decant the clear water, and evaporate the rest to dryness. But as a further precaution, we occasionally save the whole of the water decanted, evaporate it and assay the residue. In the case of the Mary Murphy, this is much richer than the sand tailings; but the proportion of solids is so small that it makes little difference.

The last time this test was made the proportion of solids in the decanted water was 0.25 per cent., which assayed:

Gold, trace; silver, 1.4 ounces; lead, 4 per cent.; zinc, 18.7 per cent.

The weight of water is about fifteen times that of the dry pulp, so that it is easily seen that the loss suspended in the water is negligible. I think every mill should make such tests at intervals, in order to guard against a peculiarly insidious form of loss; but in my experience it is rarely the case that the inaccuracy in tailing samples caused thereby is of any moment, assuming that the tailing is properly settled.

There are three essentially different ways in which to calculate mill savings: from head and tailing, from head and products, and from products and tailing. In simple mills, recovering but one or two kinds of product, it is a good plan to calculate the saving in all of these three ways, and compare the results. This is an excellent way of testing the accuracy of the sampling all through; and personally, although my own experience has generally been that I was quite unable to obtain the same result with the different methods, yet I have always thought it a very admirable plan. Nothing else calls your attention so forcibly and at the same time so promptly to the weak points of your sampling work. Even with the most complicated mill systems, it is well to take stock in this way at intervals.

Where owing to expense or other reasons only part of the sampling can be done automatically, it is clear that the tailing should be selected for this; because, after all, what primarily concerns the mill man is what he is losing, and how far it will pay him to follow it. The products are less essential to watch, because the cash account directs attention to them in the most forcible way possible; and also because the methods of sale usually ensure systematic sampling and record, even without conscious attention on the part of the operator.

It is frequently forgotten that to calculate the percentage of saving is, in itself, of no value. What we really want to know is, what is contained in the material that we are losing, and to what extent is it worth while to pursue it farther. If we are throwing away $10 per ton from a $40 ore, we are obviously losing what, under most conditions, it will pay to save. If we are losing $1 from $4 ore, it will rarely pay to attempt to recover it. Yet the percentage of saving is the same in each case.

---

**Peruvian copper production** for 1913 amounted to 27,940 metric tons, or say 27,500 English tons, an increase of 100 English tons over 1912. The output in metric tons was made up as follows: Bars, 20,340; matte, 4462; shipping ores, 3138.

# Soot-Fall Study of Pittsburgh

BY JOHN O'CONNOR, JR.

In two interesting papers contributed to your journal by John B. C. Kershaw,[1] mention was made of the fact that a study of the soot-fall of Pittsburgh had been carried on in connection with the "Smoke Investigation" of the Mellon Institute, University of Pittsburgh.

The study was made by Dr. R. C. Benner, the Chemist of the Investigation. Dr. Benner was assisted by George Edward Bost. The study began in April, 1912, and extended over a period of a year. Twelve stations were selected in different parts of the city and samples of the soot-fall were secured by exposing jars on the roofs of buildings. Glass jars about 4″ x 10″ were used in summer, and copper cans, tinned inside, in the winter.

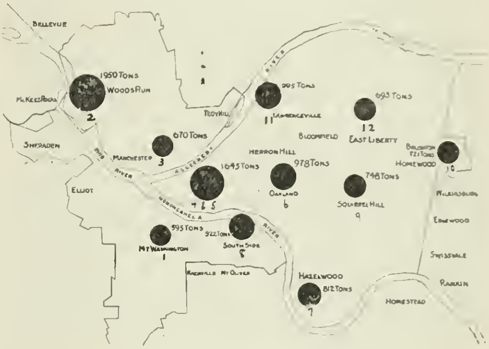
The jars were exposed for a month at a time. When a jar was brought to the laboratory, a 100 c.c. sample of the water was taken and tested for acidity with methyl-orange. If acid were found to be present, it was titrated with standard $Na_2CO_3$. The total volume of the monthly sample was determined and the total acid calculated. The month's sample was then evaporated and weighed in a porcelain dish, placed on the water bath, heated in the steam oven about 18 hours, dried in a dessicator and weighed. 1.0000 Gram of the year's dried sample from each station (of stations 2, 4 and 5, 2.0000 Grams each), was wrapped securely in a quantitative filter paper and extracted with ether in the Soxhlet extractor to determine the tar content. The extracted soot was ashed and weighed and the iron in the ash was determined by standard potassium permanganate. Table 1 shows the monthly soot-fall in grams at the different stations. The total soot-fall in grams for each station is also given and below the table is the calculated soot-fall in tons per square inch per year (See Map).

Table III shows the calculated amount in tons at each station, of tar, fixed carbon, ash and iron.

TABLE III.
SOOT-FALL IN TONS PER SQUARE MILE PER YEAR

| Sta. No. | Composition of Soot<br>Tar<br>Tons | Fixed carbon<br>Tons | Ash<br>Tons | $Fe_2O_3$<br>Tons | Total<br><br>Tons |
|---|---|---|---|---|---|
| 1 | 13 | 131 | 306 | 145 | 595 |
| 2 | 16 | 713 | 809 | 412 | 1,950 |
| 3 | 10 | 202 | 189 | 269 | 670 |
| 4 | 19 | 417 | 844 | 380 | 1,660 |
| 5 | 21 | 357 | 704 | 548 | 1,630 |
| 6 | 4 | 322 | 343 | 309 | 978 |
| 7 | 8 | 300 | 309 | 195 | 812 |
| 8 | 7 | 286 | 419 | 210 | 922 |
| 9 | 5 | 211 | 344 | 188 | 748 |
| 10 | 3 | 274 | 336 | 108 | 721 |
| 11 | 8 | 391 | 378 | 218 | 995 |
| 12 | 7 | 200 | 333 | 153 | 693 |

It is unfortunate that these figures cannot be compared with those obtained elsewhere, as, for instance, in London, Leeds, and Glasgow, because the method used in each place was different. Mr. Kershaw's plea for the adoption of a uniform system as that suggested by the committee named at the "International Smoke Abatement Exhibition and Conference," held in London, in March, 1912, becomes apparent at once.



SOOT FALL MAP OF PITTSBURGH

TABLE I.
PITTSBURGH'S SOOT-FALL SAMPLES IN GRAMS PER MONTH, APRIL, 1912, TO APRIL, 1913.
STATION NUMBERS

| Month | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1912 | | | | | | | | | | | | |
| April | .3806 | .5106 | .2722 | .5308 | .5501 | .4186 | .1184 | .2596 | .1821 | .1341 | .2599 | .1603 |
| May | .1081 | .4146 | .1142 | .5198 | .5882 | .0873 | .1384 | .1915 | .1332 | .1192 | .1676 | .2778 |
| June | .2552 | .5714 | .2752 | .4872 | .4000 | .3604 | .2142 | .3306 | .1863 | .1374 | .2026 | .1315 |
| July | .1450 | .6924 | .2570 | .3900 | .5520 | .2282 | .2030 | .3364 | .1732 | .1564 | .2078 | .1938 |
| August | .1104 | .5154 | .1460 | .2608 | .3570 | .1828 | .2022 | .2266 | .1732 | .1142 | .2024 | .1210 |
| Sept. | .1114 | .5038 | .1910 | .2022 | .3278 | .1830 | .1832 | .2040 | .1826 | .1282 | .2136 | .1426 |
| Oct. | .1380 | .5610 | .2182 | .3124 | .4622 | .2488[1] | .2072 | .3254 | .1664 | .1636 | .2942 | .1554 |
| Nov. | .0526 | .7700 | .1290 | .2188 | .3860 | .2166 | .2076 | .1734 | .1586 | .1836 | .2088 | .1742 |
| Dec. | .1380 | .7522 | .3428 | .4896 | .3788 | .3988 | .2860 | .1484 | .4282 | .3702 | .4276 | .2518 |
| 1913 | | | | | | | | | | | | |
| Jan. | .1278 | .5232 | .2660 | .6398 | .2828 | .2742 | .3092 | .2456 | .2094[2] | .3154 | .3206 | .1948 |
| Feb. | .1034 | .6200 | .2642 | .4574 | .3746 | .2042 | .0914 | .1462 | .1278 | .1420 | .2894 | .1242 |
| March | .1550 | .5438 | .1956 | .5876 | .3342 | .1972 | .3236 | .3346 | .1750 | .2462 | .1924 | .1946 |
| Total sample | 1.8255 | 6.9784 | 2.6814 | 5.0964 | 4.9937 | 3.0001 | 2.4846 | 2.9223 | 2.2960 | 2.2075 | 3.0469 | 2.1220 |
| Tons per sq. mile | 595 | 1,950 | 670 | 1,660 | 1,630 | 978 | 812 | 922 | 748 | 721 | 995 | 693 |

[1] The October jar from station No. 6 was broken, and the weight of the soot-fall for this month was calculated by taking the average monthly soot-fall for the other ten stations during the entire year, combined with the average monthly soot-fall for station No. 6 for 11 months.

[2] The January sample from station No. 9 froze and the jar was broken. The weight of the soot-fall was calculated for the month of January by taking the average monthly soot-fall for the other 10 stations during the entire year, combined with the average monthly soot-fall for station No. 9 for all eleven months.

Table II shows the per cent. analysis of the year's sample for tar, ash, fixed carbon, iron in the ash, and iron in the deposit.

TABLE II—PER CENT ANALYSIS OF YEAR'S SAMPLE OF EACH STATION

| Number of Station | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tar | 2.19 | 0.82 | 1.56 | 1.12 | 1.26 | 0.36 | 1.00 | 0.74 | 0.62 | 0.42 | 0.76 | 1.04 |
| Ash | 75.84 | 62.60 | 68.30 | 73.77 | 76.82 | 66.68 | 61.94 | 68.20 | 71.16 | 61.42 | 59.96 | 70.14 |
| Fixed carbon | 21.97 | 36.58 | 30.14 | 25.11 | 21.92 | 32.96 | 37.06 | 31.06 | 28.22 | 38.16 | 39.28 | 28.82 |
| $Fe_2O_3$ in ash | 32.08 | 33.73 | 58.78 | 30.98 | 43.66 | 47.44 | 38.44 | 33.38 | 35.42 | 24.05 | 36.52 | 31.47 |
| $Fe_2O_3$ in deposit | 24.30 | 21.10 | 40.10 | 22.90 | 33.60 | 31.60 | 23.80 | 22.80 | 25.20 | 14.80 | 21.90 | 22.10 |

At the Convention of the "International Association for the Prevention of Smoke," held in Pittsburgh, in September, 1913, at the suggestion of Bailie Smith f Glasgow, Scotland, a committee was appointed of which Mr. E. P. Roberts, the Smoke Inspector of Cleveland, was made chairman, to induce cities of the United States to take up the method suggested in England.

---

[1] Methods for investigating and recording atmospheric impurities, including the soot and dust suspended in the atmosphere, June, 1913, Vol. XI, No. 6, p. 339.

Notes on the standard apparatus and method for measuring the amount and character of atmospheric pollution, November, 1913, Vol. XI, No. 11, p. 615.

It is to be hoped, that this committee will be successful in its work and that in the near future cities of the United States will be able to compete by means of a uniform method, in an effort to show a low atmospheric pollution.

Mellon Institute of Industrial Research,
University of Pittsburgh.

---

## A Successful Method of Amalgamating in Cyanide Solution

BY JOHN RANDALL

In case coarse gold is encountered in the cyanidation of ore, the question of amalgamation is not so important as formerly. When separate treatment of sand and slime was the general practice the question was quite important, but the problem was never satisfactorily solved. With the prevalence of all-sliming the case is quite different. The ore travels in a closed circuit through the fine grinder and classifier until reduced to slime, and any coarse gold which may happen to be in the pulp is thus "worn out" and gives no trouble in the extraction department. Therefore, in all-sliming mills it is considered good practise to simplify the process by cutting out amalgamation, even when the ore contains coarse gold.

However, there are cases in which it is best to treat a part of the ore as sand, and then if it contains coarse gold the question of amalgamation comes up. To crush in water, amalgamate, dewater and then treat with solution occasions a loss of cyanide besides complicating the process; while amalgamating in cyanide solution has its drawbacks. In the latter case we have the gold cleaned and brightened by the cyanide solution and in the very best possible condition for amalgamation, but we are confronted by new difficulties. The solution attacks the plates, rapidly eating them away, while the amalgam is hardened by the dissolution of the mercury until it becomes unmanageable and the plates inefficient. The difficulties encountered have generally been sufficient to result in the abandonment of amalgamation in cyanide solution after many careful and persistent efforts.

It is the object of this article to bring into notice a phase of the subject which seems to have escaped general attention.

It is well known that if metallic sodium be mixed with mercury and immersed in a watery solution the action of the sodium in going into solution as NaOH at the surface of the mercury will produce practically the same result as that occurring at the cathode of an electrolytic cell. If there is gold or other metals in the solution they will be deposited upon the surface of the mercury and amalgamated. But in plate-amalgamation the mercury and sodium is spread out into such an exceedingly thin film that the sodium is rapidly oxidized and carried off, the good effect of it being noticeable for only a very short time after dressing the plates. This is the main reason why amalgamators generally regard sodium as of little or no value.

### Riffles Substituted for Plates

However, if riffles containing mercury be substituted for plates the last named difficulty is overcome, and it is possible to keep the quantity of sodium in the mercury fairly constant. Some time ago the writer was in charge of a mill, treating sand and slime separately, where gold nuggets the size of a pea were sometimes found, although the ore averaged a little below $10 per ton gold. The ore was a weathered dump and contained some copper as azurite, but no native copper. The crushing was done in solution in a Chilean mill through 16-mesh screens. The mill was provided with plates, but they were taken out and riffles were substituted.

In cleaning up it was found that the greater part of the amalgam was so fine that it could be squeezed through chamois leather, and the bullion from the riffles was found to contain about two pounds of copper for each ounce of gold and silver. It is evident that the copper was deposited from the solution, and that in addition to recovering free gold that passed through the screens, the riffles had been of service in mitigating troubles arising from copper in the zinc boxes.

It was aimed to keep the amount of sodium just below the point where the mercury would amalgamate a freshly brightened iron nail. To accomplish this some mercury containing a large amount of sodium amalgam was kept on hand in a dry, glass-stoppered bottle and a determined amount of this put into the riffles every four hours. No mercury was detected in the solution, and as none was floured, a weighing at the end of the run showed no loss except what might be expected in retorting.

### Returning Part of Riffles Discharge by Tailing Wheel

In operating riffles it is found that those of the best design will choke when the feed is temporarily diminished below full capacity, and some trouble is experienced in getting them started again. This trouble may be obviated by placing a small tailing wheel in such a manner that it will return a variable amount of the outflow back to the head of the riffles as shown in Fig. 1. By this means riffles of comparatively large capacity may be operated on a small amount of pulp. A section of the feed spout may be made to slide in telescope style, or a movable partition may be placed in the spout to cut out a variable amount of pulp.

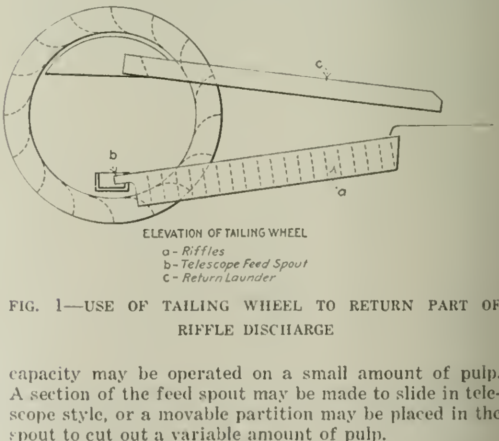


FIG. 1—USE OF TAILING WHEEL TO RETURN PART OF RIFFLE DISCHARGE

I think it very doubtful if it would pay anybody to make riffles should they desire to use them with mercury, for this or any other mill purpose. The Pierce riffles, called the Pierce amalgamator, can be depended upon if given the proper amount of feed, and the sodium will protect the metal parts. They look somewhat expensive in first cost, but any riffles that will hold mercury and not pack with sand are open to the same objection. In operating riffles it is quite necessary to have a screen above them to intercept gravel that may occasionally come from a broken mill screen.

Boulder, Colo.

---

The Alaska Gold Company expects to have its immense mill ready for operation before the end of this year as planned. Excavations have been completed and erection of steel should commence this month.

# Mechanical Refrigeration—III

## The Absorption Refrigerating Machine

BY H. J. MACINTIRE

The absorption refrigerating machine, although one of the first designs for artificial cooling, has only recently been given the careful attention necessary for economic results, but now its construction has been so perfected as to give it an unassailable place in the refrigerating industry. Yet the operation and details of the cycle are so foreign to common steam-engine practice as to cause considerable trouble to those unfamiliar with it. It is hoped that the following will be so presented as to make the working of the machine seem as perfectly clear and simple as it really is.

Before taking up the design of the absorption machine in detail the few similarities to the compression machine and the notable differences of the two will first be pointed out. The condenser and cooler are identical in both machines. The compression machine uses an anhydrous refrigerant, whereas the absorption machine uses ammonia only—part of the time as a solution in water and the remainder of the time as nearly anhydrous ammonia. The compression machine compresses the vapor by the displacement of the piston driven by a heat engine or electric motor. The absorption machine utilizes the heat in the steam directly to separate the ammonia out of its solution (thereby leaving a weak aqua in the still) and to drive it finally into the condenser where it is condensed by the action of cooling water as in the other type of machine. In order to provide continuity of action the vapor from the cooler must be returned to the still or generator by combining it in solution again with the weak aqua from the generator. The absorption machine has no moving parts except a small pump, and uses the heat energy in the steam. There is, in fact, no reason why atmospheric exhaust steam may not be used to advantage in most cases, provided the absorption machine is designed with the necessary heating surfaces in the generator for this condition of operation.

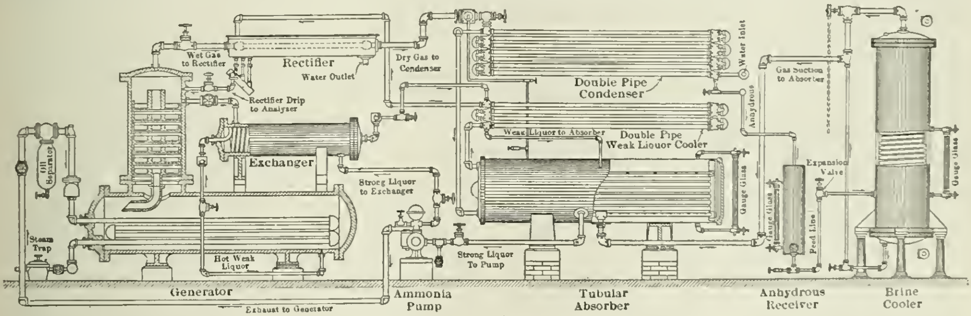


FIG. 1

### THE ABSORPTION CYCLE

Let us refer to Fig. 1 and consider the absorption cycle in detail. The generator is usually a cylindrical shell containing a solution of ammonia, from 30 per cent to 35 per cent in weight, and a number of steam coils connected in front to steam headers. The action of heat tends to dissociate the ammonia from the solution, and the ammonia, as well as some water vapor (under a pressure slightly in excess of the condenser pressure) pass into the upper portions of the generator called the analyzer. In the latter is a counter-current of strong aqua colder than the vapor arising which condenses most of the water vapor and cools the ammonia vapor of some of its superheat, an operation which is nearly completed in the water or air-cooled dehydrator. The analyzer and dehydrator also act as a check to excessive ebullition in the still and tend to prevent the aqua of the generator from boiling into the condenser, which would preclude further refrigeration. Drips from the dehydrator pass by gravity into the generator.

The vapor from the cooler must be returned to the generator in the form of a solution or strong aqua. To do this the weak aqua from the generator is first cooled and then sent into the absorber where it comes into intimate contact with the vapor from the cooler. The pressure in the absorber is but slightly lower than that in the cooler (some 10 lb. to 35 lb. absolute) and the temperature of the weak aqua entering the cooler is from 80 deg. Fahr. to 110 deg. Fahr. The result is that the affinity of the cool weak aqua is quite strong for the ammonia and a stronger aqua results with a liberation of heat which must be removed by cooling water or the temperature will rise and prevent satisfactory operation. The strong aqua, cooled to about 90 deg. Fahr., and at a pressure of one or two atmospheres must be returned to the generator under a pressure of eight or twelve atmospheres. As the weak aqua had to be cooled before admittance to the absorber and the strong aqua requires heating before being pumped into the generator very excellent results are obtained by the use of a counter-flow exchanger—usually of the double-pipe (one pipe within the other) construction. The hot weak aqua then proceeds from the generator, through the exchanger, where it gives up its heat to the strong aqua and then enters the absorber. The heated strong aqua is piped into the upper part of the analyzer, where it flows by gravity into the generator and cools the ascending hot gases being driven off from the generator.

In summing up, the analyzer and the dehydrator provide a means for moderate cooling of the ammonia vapor and nearly perfect separation of the water content. The exchanger increases the efficiency of the plant by saving steam in the generator and cooling water in the absorber. The generator and the absorber are the two important, distinctive absorption features. The condenser and cooler are identical with those used for the compression form of refrigerating machine.

Keeping in mind the general construction of the two principal designs of refrigerating machines and their cycles, it is desirable now to make a brief comparison of them. The compression machine utilizes the expansive force of the steam which does work on a piston, which likewise in turn does work on the refrigerating medium. The steam is usually taken at boiler pressure into the cylinder of the steam engine and is exhausted (except for the larger machines) into the atmosphere or into heating coils at nearly atmospheric pressure. The percentage of heat in the steam converted into useful work is usually not in excess of 10 per cent and often is much less. The absorption machine transfers the heat in the steam to the aqua in the generator. As the steam condenses, the heat given up to the aqua is between 900 and 1000 B.t.u. per pound, and the efficiency of the conversion is approximately 75 per cent.

The greatest point in favor of the absorption machine, speaking economically, is that it may be designed to use exhaust steam, and requires power only for the strong aqua pump and such other auxiliary apparatus as apply to the particular installation—such as brine-circulating and deep-well pumps, fan for the circulation of air, etc., and the exhaust from these (if steam-driven) may be employed in the generator. Also in a properly designed and compact grouping of the separate machines the decrease of the cooler pressure does not offer any difficulties and the cost of a ton of refrigeration (cooling at the rate of 200 B.t.u. per minute) does not increase very much with low refrigerating temperatures. Brine temperatures of — 10 deg. Fahr. or — 20 deg. Fahr. are readily and economically obtained. The absorption machine, however, is more costly as a rule and covers more space than an equally sized compression machine. Considerably more ammonia is required for charging, and the loss due to leaks and disintegration is greater.

As has been stated exhaust steam may be used in the absorption machine, and also that 75 per cent to 80 per cent of the heat in the steam passes into the aqua of the generator. Such being the case, it would seem at first that the absorption machine is by far the most economical of all refrigerating machines and that where exhaust steam was a by-product the compression machine could not possibly be a competitor. Yet, although certain advantages can be claimed for the absorption machine, it does not give in practice the economy of operation that it would seem capable of. According to competitive tests it has been found that about 30 lb. of steam per hour per ton of refrigeration is required for either type of refrigerating machine.

The reason for this lack of good showing on the part of the absorption machine may be seen by considering the analysis of the heat necessary for the operation of the generator per pound of ammonia condensed in the condenser, taken from an actual test.

| | |
|---|---|
| 1. Heat of solution at average concentration of aqua (31.8%) | = — 193.0 |
| 2. Difference in heat of the liquid above saturation (129.7 — 63.7 × 1.154) | = + 77.4 |
| 3. Heat of vaporization at temperature of saturation (from condenser pressure) | = — 518.1 |
| 4. Heat necessary to superheat the vapor (0.52 × [152.0 — 62.7]) | = — 47.5 |
| 5. Heat necessary to heat the strong aqua to the temperature of the outgoing weak aqua (6.65 × 50.1 × 1.018) | — 349.0 |
| Total | — 1030.2 |

This very large total of 1030 B.t.u. per pound of ammonia condensed requires from 26 lb. to 34 lb. of steam per ton of refrigeration per hour, depending on the operating conditions. Items 1, 3 and 4 are inevitable and vary but little with different conditions of operation. Item 5 could be eliminated by supplying the strong aqua to the generator at the temperature of the aqua leaving the generator. As this is impossible without supplying additional heat, the only means of making this item small is to have little aqua in circulation per pound of ammonia condensed, namely, by the use of large differences in the concentrations of the weak and strong aqua. Usually the number of pounds of weak aqua circulated per pound of ammonia condensed is much greater than in the case above (6.65), especially if care is not given to the operation of the machine. However, where exhaust steam is available and cannot be otherwise used, the absorption machine is generally the best refrigerating machine to employ.

University of Washington,
Seattle, Wash.

# The Igneous Concentration of Metallic Values from Mixed Sulphides—I.

BY F. L. CLERC

In the earlier paper, on the "Igneous Concentration of Zinc Ores,"[1] I directed attention to three well known processes of manufacturing zinc pigments, or of pigments containing zinc, and suggested modifications in certain particulars, to adapt them to the concentration of zinc as a sublimed product.

In reference to my present subject, I made the following statement: "Much is to be expected from pyritic smelting if concentration (of values) at the top of the furnace becomes an object of consideration."

In returning to the subject, it may be well to state clearly at the outset what I shall attempt to do, and what I wish to avoid even the appearance of trying to do.

The igneous concentration of copper in the form of matte, from ores carrying only a few per cent of copper, and the production of metallic copper from these mattes, has had a phenomenal development in the last twenty years, and has established itself in all quarters of the world.

I do not propose to write even an outline history of this development. Nor do I propose to examine into technical details, or to try to explain variations in practice imposed by local conditions.

The idea underlying much of this progress is to utilize, as far as is practicable, the heat evolved by the rapid oxidation of sulphur and the metal with which it is combined, to carry on the smelting operation. The object of metallurgy is to separate a metal from its ores, and in some cases from other metals. Carbonaceous fuel is needed in most igneous processes to supply the heat required; in so far as this heat can be effectively generated by metals and metalloids, less carbon will be required.

## Relation of Pyritic Processes to the Igneous Concentration of Zinc

In applying this principle of the generation of heat by the rapid oxidation of metallic sulphides to the closely related subject of the concentration of zinc by sublimation from mixed sulphides, it is important to know what it has done for copper metallurgy, and to inquire a little into its theory, how it has affected practice, and along what lines it has been developed. There are two classes of metallurgists who are likely to become interested in the igneous concentration of zinc. First: Those copper smelters whose ores carry an appreciable amount of zinc; to them my treatment of the subject may appear superficial and inadequate. The other class are those who have to do with ores of zinc intimately mixed with other sulphides, but who have not had practical experience in copper smelting. These latter may find, by looking into the subject, that they can profitably make use of a source of heat which the copper smelters have quite fully utilized.

I propose then, in a very general review of the subject, to select a few notable events, as a traveler in a strange country marks his course by land marks. I choose as the events by which progress is marked public demonstrations on a commercial scale, which have been adequately reported upon.

The account here given of these demonstrations is taken from the Presidential address of Mr. Robt. C. Sticht read before the Australasian Association for the Advancement of Science, at the Adelaide meeting in January, 1907. By referring the reader to this address for a connected story of the earlier investigations and discoveries, which prepared the way for these experiments, and for a connected account of what has been done since, I can bring my subject within the limits of a single article, and in some measure trace the application of the idea. The demonstrations chosen are: First. The experiments of three Russian metallurgists in Bessemerizing copper matte, the results of which were published in the Russian Mining Gazette of May, 1870, and also in Berg und Hüttenmannische Zeitung in 1871. Second. John Hollway's experiment with copper ores in 1878-9, reported to the Society of Arts February 12th (or 22d?), 1879. Third. The introduction of the process of Bessemerizing copper mattes at the Parrot Works in Montana under the supervision of agents of Manhés. Fourth. The revival of Holloway's process, with modifications adapting it to then prevailing conditions in Montana and Colorado, by W. L. Austin and others. Fifth. The establishment of a great copper industry at Mt. Lyell in Tasmania.

---

[1] *Eng. and Min. Jnl.*, Jan. 13, 1912, p. 127.

### Definition of Terms. "Pyrite" or "Pyritic?"

Before recounting these events, it is desirable that a clear understanding should be reached as to the meaning of certain terms which must be used. These words are used by different authorities to convey different meanings. Thus we have "pyritic" smelting and "pyrite" smelting, also "pure" and "partial pyritic" smelting, or "pure" and "partial pyrite" smelting, a needless assortment of names, resulting in some confusion of meaning.

It has been urged by some against the adoption of "pyritic" smelting as a generic name to classify a group of allied processes, based on the utilization of the heat evolved by the rapid oxidation of sulphur and metallic bases, by means of an air blast, that this name was appropriated by John Percy for the iron-matting process, long practiced in Europe, in which unroasted iron sulphide was added to the charge for the purpose of collecting the precious metals it contained, in an iron matte. As these metals were extracted from the matte by means of lead, since a cupriferous lead bullion was troublesome to treat, copper was excluded from the charge as far as was practicable. The force of this objection is somewhat weakened by the now recognized fact that the heat of combustion of the iron sulphide was to some extent utilized to carry on the operation. Moreover, this process is not deposed from its proper class as one of the pyritic processes; it still holds its position as one variety of pyritic processes. It is not unusual in scientific classification, where a single species has been the sole representative of a genus, and is given a comprehensive name, to transfer this generic name to a class of similar things discovered later, which have to be classified, and to relagate the first species reported to a subordinate position.

A more serious objection can be made to the name "pyrite" smelting. Pyrite is a name coined to accurately denote a particular mineral, $FeS_2$, and distinguish it from other metallic sulphides occurring as ores, and include in mining and metallurgical parlance in the general term of "pyrites." Used as a noun in connection with smelting, the sense may be altered with the preposition required to correct the ellipsis. It is not the smelting *of* pyrite, nor the smelting *with* pyrite, nor even the smelting *by* pyrite, that conveys the meaning intended. Unless "pyrite" is used adjectively, and deprived of its specific meaning, a whole class of minerals more or less included under the popular name, pyrites, are excluded by definition from this process of treatment.

"Pyritic" is an adjective properly formed from pyrites. Like all adjectives, it cannot be understood in an absolute sense. It qualifies a noun and reflects either an individual opinion or a principle of classification. "Pyritic" smelting, then, means smelting, best distinguished from other smelting in some way closely related to the group of minerals called pyrites. The definition of the genus will then determine what processes are included in it. This definition will not exclude the processes described as follows: "The practice of pyrite smelting is based upon the utilization of the heat derived from the combustion of sulphide ores, in a blast furnace, in contradistinction to the heat obtained directly from carbonaceous fuel."[2] Nor with this: "We will therefore call pyritic smelting the art or practice of smelting a charge, in which all the iron present is combined with sulphur to produce a ferrous silicate slag."[3] "The allowable amount of coke in the charge is considered immaterial. A distinction based on it is only conventional."[4] On the other hand, it includes a number of closely allied processes. It will include the production of metallic copper from matte, the enrichment of mattes, as well as the production of mattes from the sulphide ores. These different processes can be distinguished from each other, but all are based on the same theory which is the standard of classification. Under this classification a furnace would not run one day on a *pure* pyritic process, and another day on a *partial* pyritic process, and we need not inquire as to the intention of the operator, or as to his knowledge of what is going on in his furnace.

### Historical Events

The Russian experiments were under the direction of M. Semmennikow, governmental head of the department. After a few preliminary tests with small quantities at the Bogolowsk copper plant (1867), they were repeated on a larger scale at the steel works near by, at Watkinsk. These tests, as to the suitability of copper mattes for the Bessemerizing process, were carried on by A. von Jossa and N. Laletin. The results, as referred to by Mr. Sticht, may be summarized as follows: The tests were made in rather small charges, but in all 18,000 lb. of matte containing 31.5 per cent Cu were treated. Fifteen tests in all were made, including the enrichment of 31.5 per cent Cu mattes to 72-80 per cent Cu, and the further refinement to 80-95 per cent Cu. The final matte was worked up on the speissofen, according to the practice of the time. The experiments were made in an oval converter, designed for Bessemerizing pig iron, which had a height of 5 ft. and a greatest diameter of 4 ft. 2 in., which treated from 1600 to 2000 lb. of matte at each "blow." The air pressure used varied from 4 to 12 pounds per square inch. High pressure involved the ejection of molten material; low pressure resulted in the closing of the tuyeres, which necessitated frequent cleaning. There were seven tuyere bricks in the bottom of the converter, each of which contained five vertical openings $^3/_8$ of an inch in diameter. In some of the experiments, all except 6 to 10 of the openings at the bottom were closed, and two supplementary horizontal tuyeres, $1^1/_2$ inches in diameter, were inserted tangentially at the bottom.

The slag formed during the operation was lifted off in chilled layers, and was not skimmed or poured.

The attempts to bring 95% Cu mattes up to metallic copper were less favorable. This was probably due to the small amount of rich matte treated, in all 720 pounds were so used, and on pouring much of it remained as a skull adhering to the walls of the converter. With a larger charge, a greater proportion could have been poured. The expedient of "double banking," i. e., blowing successive charges before pouring was not tried.

---

[2] T. A. Rickard, *Pyrite Smelting*, p. 9.

[3] Geo. A. Guess, *Eng. and Min. Jnl.*, Jan. 13, 1912

[4] Idem.

These Russian engineers clearly understood that a large part of the heat developed in the first stage of the operation (with low-grade mattes) came from the oxidation and slagging of the iron; the oxidation of $Cu_2S$ to produce metallic copper being more important in the second stage. They clearly distinguished between the two stages by the end of phenomena of color and character of flame. They were influenced, perhaps unfortunately, by the tendency of the times, to experiment extensively with the injection of steam with the blast. They were somewhat hampered by the crudity of the apparatus employed, but even in this respect they were more fortunate than other early experimenters, and were especially qualified by their experience in Bessemerizing iron and converter manipulation to conduct these experiments. The cold matte was separately melted and run into the converter.

Their conclusions, in brief, are as follows:

Bessemerizing copper matte by means of superheated steam alone, or admixed with air, is scarcely practicable. Production of black copper, 95 per cent Cu, by the application of highly compressed air, is perfectly feasible, but likely to be unprofitable, partly because of wastage of copper and partly because of accretions of copper on the converter walls. But the process of Bessemerizing low-grade copper matte is deserving of the greatest attention, and may be of the greatest utility, under the following conditions: (a) The matte should be run hot into the converter; (b) the operation should only be continued to the point where the charge consists of one equivalent of $Cu_2S$ to 0.12 of an equivalent of FeS; (c) the regulus should be brought up to black copper in the ordinary way, in a roaster furnace having a number of air tuyeres.

The advantages claimed by this new process, even thus restricted, were a notable saving of time, fuel and labor. Mr. Sticht sums up: "With these Russian experiments * * * the pneumatic process, as applied to copper mattes, was fairly launched. At all events, the availability of sulphide substances as sources of great heat under conditions which accelerate the chemical phenomena of ordinary copper smelting processes was completely established," etc.

John Hollway's experiments[5] in treating ore were made with the use of low grade Rio Tinto pyrites, at Messrs. Cammell & Co's. steel plant in 1878-9, the ordinary Bessemer paraphernalia being employed. The pyrites were melted down in a cupola furnace, and blown in regular 6 ton vessels, with 20-lb. air pressure. All phenomena were scientifically scrutinized; temperature, flame, composition of gas and molten products, etc. Among other things, he succeeded in running one converter on pyrites and quartz for fourteen consecutive hours, with repeated charging, and with the total exclusion of carbonaceous fuel, other than that used to provide the blast.

Altogether his trials demonstrated to the members of the Society of Arts, for whose benefit a special exhibition was given, "that pyrites carrying copper could be made self-smelting, and was a metallurgical fuel of the utmost efficiency; that the waste of its fuel qualities in current practice could be obviated; that a high ratio of copper concentration was achievable; that a complete utilization of atmospheric oxygen was affected," etc. Mr. Sticht regards these tests as a brilliant contribution to metallurgical art, and the report upon them as one of the classics of metallurgical literature.

The foregoing apparently successful commercial tests by Semmenikow and Hollway were not immediately followed by the building up of a new metallurgical industry, but the underlying idea inspired other investigators like Manhés and David in France, who developed the Bessemerizing of mattes. Mr. Sticht attributes the rapid expansion of pyritic smelting since 1885 to the transplanting of the process to newer fields of activity where an abundance of suitable ore, and the ingenuity of metallurgists, unhampered by conservative traditions, offered most favorable conditions. The events to be noted are:

"Six converters of the permanent plant at the Parrot Silver & Copper Co.'s works, at Butte, Montana, were completed in 1885, at the instance of Mr. Franklin Ferrell, Pres't, and under the supervision of agents of M. Manhés. Subsequently, American inventive genius, favored by economic conditions, has improved on the construction of converters and all accessories, and upon their operation. The Bessemerizing of copper mattes was thus put on a sound basis. At first, the mattes treated were kept at 35 per cent Cu, later the advantage of a 50 per cent Cu matte was seen, and this grade of matte was produced." Many workers contributed to this rapid advance. It is quite apart from my theme to award praise or to enter upon the question of priority.

To follow Mr. Sticht still further:

The urgent demands for copper mattes to keep the converters in operation directed attention anew to Hollway's experiments. "The interest in the rapid oxidation of sulphide ores, as spontaneous fuels, was revived by Mr. W. L. Austin. He with others took up the 'raw smelting' innovation, and perfected it in the new light, etc. Following in the footsteps of Mr. Hollway, and modernizing his operative scheme, the true pneumatic pyritic principle, but supported by the use of a hot blast, was at last brought to some degree of practical perfection. This was effected in Montana between 1887 and 1891, and was subsequently further pursued in Colorado."

"It was, however, reserved for Australia to demonstrate finally and conclusively that 'pyritic smelting' * * * is wholly suitable for copper ores of any grade, and is not afflicted with a greater wastefulness through scorification, or other source, than current older methods, etc. The special opportunity came at Mt. Lyell, Tasmania, in 1896, etc."

From these two nurseries, the mining regions of the Rocky Mountain states, and of Australia, the newly established industry has spread rapidly over nearly all the copper mining districts of the world. In each new field it has advanced along special lines, more or less determined by local conditions, and must be studied in each particular case in connection with these conditions.

### Progress of Pyritic Processes

The progress in pyritic smelting of copper ores, as distinguished from Bessemerizing copper mattes, may be profitably followed in the discussions of the subject carried on in the columns of the *Engineering & Mining Journal*, 1903-1905. The principal papers were published in book form under the title of "Pyrite Smelting." These carefully considered opinions of thirty or more competent metallurgists, bring out most clearly the effect of local conditions in modifying operative details. Nevertheless, there is a general concurrence of opinion upon the underlying principle.

Of the ten questions under discussion, I will only consider three: the use of a heated blast; the addition of coke to the charge, and the effect of zinc sulphide in the charge. It was generally admitted that warm or hot blast is desirable in almost every case, if it does not cost too much; that it is indispensable in some cases, and can be avoided in others. For particulars, the papers themselves should be consulted. Coke has been entirely omitted in some campaigns. In others it has been reduced to between 1 per cent and 1½ per cent of the charge, using a cold blast, when the ore ran high in pyrite. In general, smelting with 4 per cent of coke is considered good work. The practical question is this: Whether it is cheaper to furnish a hot blast, and save coke, or to use a few more per cent of coke and put up with the inconveniences which follow its use. The drawbacks to heating the blast are the cost of the hot-blast stoves and their low efficiency in raising the temperature of the blast. In pyritic smelting the gases issuing from the furnace contain too much sulphur to be used to fire the stoves, so that additional carbonaceous fuel must be burned. Some of the objections to coke in the charge, apart from its cost, and the difficulty of obtaining a suitable quality of it, in some localities, are as follows: Theoretically, and in practice, the reducing activity of carbon antagonizes the rapid oxidation of the furnace charge, which is the basis of pyritic smelting. So far, its use is irrational, but in the present state of the metallurgical art it may be admitted that in some cases it is indispensable. To burn the coke an additional amount of oxygen must be blown into the furnace, which is accompanied with nearly four times its volume of nitrogen, which makes necessary a large blast installation. As Dr. Peters expresses it,[6] "To obtain this oxidizing atmosphere we must reduce the amount of coke until, when blowing a reasonable blast into the furnace, there will be enough oxygen, not only to burn the coke, but also to produce a highly oxidizing atmosphere with which to burn the sulphide; for, when an atom of oxygen has to choose between an atom of glowing coke and an atom of glowing sulphide it prefers to combine with the coke and the sulphide simply melts as ferrous sulphide and goes into the matte as such, and it is only the excess of oxygen that acts on the sulphide." The result is an increased amount of matte and a lower ratio of concentration. The heat supplied by the coke and its reducing action is apt to be developed at a level in the furnace where they are not desired. The occurrence of iron sows and the accumulation of $Fe_3O_4$ (magnetic oxide) reported by several observers may be due to local reactions with the coke. On the other hand, Dr. Peters considers the reaction $FeS + 2FeO = 3Fe + SO_2$ as possible. This would not occur if free silica to combine with the iron oxide were present. In connection with a hot blast and the use of coke, Messrs. Lynn & Keeney, metallurgists connected with the U. S. Bureau of Mines, suggested in a paper[7] read at the September, 1913, meeting of the A. I. M. E. at Butte, the question "Whether electric heat may be used to replace the heat which is derived from the combustion of coke in pyrite and semi-pyrite processes" * * * "would it be possible and commercially feasible to carry out these processes in an electric furnace using a blast, obtaining as much heat as possible from the oxidation of the sulphur and iron and supplying by electrical energy whatever additional heat might be needed." In the discussion of this paper[8] it was suggested that this heat could be most effectively applied to the blast.

---

[5] *A New Application of Bessemer's Process of Rapid Oxidation, by Which Sulphides Are Utilized as Fuel.* Read before the Society of Arts, Feb. 12 (or 22?), 1879

The effect of zinc in the charge is generally considered negligible if it does not exceed 10 per cent to 12 per cent of the ore. It is admitted that some of it escapes at the top of the furnace, but in general an attempt is made to throw it into the slag. The fact that zinc sulphide has a considerable calorific value, as a metallurgical fuel, is however clearly brought out in the discussion.

### Further Application of Rapid Oxidation Processes

Mr. Sticht emphasises the fact that the utilization of the heat developed by the rapid oxidation of metals and metalloids in the charge by means of an injected blast of air has found application beyond the boundaries of steel and copper metallurgy. "Witness the revolution already wrought in lead smelting by the Huntington-Heberlein, Salvelsberg and Carmichael-Bradford processes and their followers," to which may be added the Dwight-Lloyd roasting furnace. "Note the renewed interest bestowed on the question of the purification of metals by means of forced oxidation. It is not too much to say that, without the precedent of the surpassing success of the pneumatic treatment applied to copper and iron sulphides, these promising departures from established tracks in other metals would have been delayed very many years."

In a second paper I shall tabulate the calorific value of the more common metals and sulphides and compare them with carbonaceous fuels, and will suggest a simple form of apparatus to experiment on the problem of burning them effectively.

Denver, Colo.

---

**Faraday Society.**—The program of the meeting of the Faraday Society, scheduled for March 27 in London, is a symposium of papers on "Optical Rotatory Power." Papers will be presented on this subject by H. Rupe, H. Grossmann, L. Tschugaeff, T. M. Lowry and T. W. Dickson, T. M. Lowry and H. H. Abram, R. H. Pickard and J. Kenyon, T. S. Patterson. Sessions are to be held in the afternoon and evening.

**The Otto Coking Company, Inc.**, a corporation, has been formed to operate in the United States, and on March 1, 1914, has taken over the organization, assets and good will of the Schniewind Coke Oven Company, the United Coke and Gas Company, the German American Coke and Gas Company and the American Coke and Gas Construction Company. The Otto Coking Company is controlled by the interests in Dr. C. Otto & Company, of Dahlhausen a. d. Ruhr, Germany, and the Otto By-Product Coke Company, of Leeds, England. The object is to introduce into the United States the Otto Regenerative By-Product Coke Oven, with direct recovery of ammonia, tar and benzol. The new company starts out with a contract for the immediate erection of a plant for the Buffalo By-Product Coke Corporation at Lackawanna, New York, near Buffalo, with several other negotiations now going on for additional plants. The permanent officers of the new corporation will be Dr. M. G. Christie, Leeds, England, President, who will spend about half his time in this country; Dr. C. Otto, Assistant to the President, who will shortly take up his permanent residence in this country, Dr. Otto being the son of the inventor of the original Otto oven. The Vice-President and General Manager will be Mr. Louis Wilputte, one of the best known coke-oven engineers in America. The Secretary and Treasurer will be George F. McKay. The temporary offices of the corporation will be at No. 6 Church Street, New York City, where they will occupy the entire seventh floor.

**Metallic zinc production** in the United States for 1913 was the greatest in the history of the country, according to the U. S. Geological Survey. Spelter from domestic ores amounted to 337,252 tons, and from foreign ores 9424 tons, making a total of 346,676 tons. This is a gain of 2.3 per cent over the output of 1912. Missouri led in production and Illinois in smelting.

---

[6] Pyrite Smelting, p. 151.
[7] *Bulletin* No. 80, A. I. M. E., Aug., 1913, p. 2130.
[8] *Bulletin* No. 83, A. I. M. E., Nov., 1913.

# Hygiene and the Use of Ozone for Ventilation[*]

BY PROF. CZAPLEWSKI

At the congress at Frankfurt, June 10, 1909, the use of ozone for ventilation was treated by W. Cramer. Today this subject is treated in detail by myself and by Mr. Cramer, and the reason for these two reports is that after a period of praise for ozone in ventilation there has succeeded a wave of disapproval and objection. It is only just that we go over the field and see what we can say for and against ozone. The following article gives the truths about ozone and its hygienic importance in purifying and improving the air and its use in artificial ventilation.

In nature ozone is found in the air after lightning and rains during a thunderstorm. The quantities of ozone are, as Wolpert shows, so small compared to those produced artificially as to have little importance hygienically. Davy claims that this quantity is 1 mg. in 100 cbm. air; Wolpert says it is impossible to determine accurately the small quantities of ozone formed in the air, as any ozone in the atmosphere is decomposed by organic matter and gaseous impurities. The air in inhabited places is poorer in ozone than in the country, and in closed rooms the air has no ozone at all. Houzeau, Fox and Wölffhügel all attest this. The ozone percentage increases with the height above the ground. The maximum percentage of ozone is found in May, the minimum in November.

It is believed that the impurities which arise from animals and man are destroyed in the air by ozone, which is thus used up. The hygienic quality of the ozone in the air thus is of a negative character, since the air becomes purer, not because of the presence of ozone, but because the ozone is utilized to oxidize the impurities and dust particles.

Investigations on the influences of ozone on disease bacteria were taken up successfully in 1891 by Fröhlich. The work done by Ohlmüller led to this conclusion: "The ozone has a destructive action on bacteria when the water is not too much contaminated with lifeless organic substances." Sonntag was not able to prove a bactericidal effect with dry ozone, nor did Konrich get very encouraging results. Filter paper, dipped in bouillon cultures and dried, was exposed to the ozone in a glass vessel without becoming sterilized. The same was true when the bacteria were dried on glass rods, thus bacteria are not killed by dry ozone. Better results were obtained when the ozone was used on wet filter paper. There were killed in glass vessels with simultaneous moistening by steam: after 1 hour, typhoid, para-typhoid B., dysenteric, Shiga-Kruse; after 2 hours, dysentery-Flexner; after 2 to 3 hours, Coli; after 3 hours, para-typhoid B. pyocyaneous, prodigiosus, sarcina aurantiæ, sarcina flava; after 4 hours, tetragenus; after 2 to 4 hours, staphylococcus aureus (not quite certain); after 4 hours, not yet: spores of anthrax and subtilis.

Bail says there is no question that ozone dissolved in water has a bactericidal effect of the highest order, and sometimes such an effect might exist in air ozonization, as in cold storage for meats.

Kuckuck states that in the Heidelberg public bath he reduced the air bacteria 50 per cent with ozone. Labbe noticed a great decrease in the germs in the room, even with the curtains and handings drawn.

We may assume that the tests so far have not given conclusive results regarding sterilizing effect of ozone in air. More favorable results have, however, been obtained with actual ozone ventilation, especially in egg and meat cold storage plants. It is indisputable that the introduction of ozone into ventilation has resulted in better preservation of meat and prevention of moulds; the cut faces become hard and there is a saving because less of the surface cuts need be thrown away because of mould. There seems then to be an unmistakable antiseptic effect of ozone. In such operations we have, however, stronger ozone concentrations, and besides the bacteria do not grow as rapidly in the low storage temperature, are weaker, and there is the surface hardening which makes it more difficult for bacteria to procreate and thrive.

*Effect of Ozone on Dust.*—If ozonized air is passed through long glass tubes, it loses some ozone; the ozone is used for the oxidation of the organic contents in the tubes. This was found by Fox and Wolffhügel.

*Effect of Ozone on Odors.*—Erlandsen and Schwarz stated, basing their opinion on the fact that the odors reappeared, that it is a matter of covering odor, not removing odor, and that we deal with a similar case when decaying material or fecal matter is covered with carbolic acid, and the latter odor overcomes the former without destroying it.

The two opinions, destruction of odor and covering of odor, stand diametrically opposite to each other. Konrich goes, perhaps, farthest when he ascribes to ozone merely a perfuming effect.

*Disposal of Odor.*—Most chemical substances have some odor, and many are scents, often very powerful; some are simple, others complex. Among the simple scents are chlorine, bromine, hydrogen sulphide, iodoform, and among the more complex, merkaptane, indole, skatole, trimethylamine, etc. There are substances which do not themselves smell but which become odorous under the influence of heat or moisture, e.g.: trioxymetheline in itself is odorless, but when decomposed gives a strong, penetrating formaldehyde odor; hydrogen sulphide is produced by the decay and decomposition of sulphurous metals and alkalies.

In the disposal of odors we differentiate between odor distributed in the room, that can be removed by ventilation, and fixed odor, or odorous substances that cause odors and are, therefore, permanent sources, as, e.g., odor *fixed* on the surfaces of objects in the room. This depends on the *quality* of the surfaces, whether of porous or impervious materials. With smooth and impervious surfaces, as metal, glass, porcelain, stone, oil coatings, furniture polish, varnishes and lacquers, we must consider also their heat conductivity. When they cool there may be a deposit of moisture through condensation of water vapor, which occurs the more rapidly the greater their specific heat and conductivity coefficient.

With pervious materials we must differentiate between porous and hygroscopic properties. The former absorb air and water vapor only into their pores, the the latter absorb water vapor and with it, probably also, dissolved gaseous substances. When the temperature is lowered the air or water vapor enclosed in the pores contracts; when the temperature rises the volume increases and liberates the water vapor and the absorbed gases. This is important in connection with the appearance of obstinate after-odors. Of the hygroscopic substances, animal textures like wool, silk, hair, fur and less so the vegetable textures like cotton, linen, pure cellulose, absorb odors readily. The persistent odors which cling to clothing and hair after exposure to tobacco smoke often prove as disagreeable as does cold smoke itself.

We must deal, therefore, with simple absorption, in porous surfaces and also possibly with a chemical action as through hygroscopic surfaces. We must also consider the character and area of the surface, which depend a good deal on the surface development in the room. Odors will stick much longer to rough, porous walls whitewashed and coated with linseed paint, hangings, tapestries, upholstered furniture, because these absorb them, while smooth and impervious walls, smooth furniture, lack of hangings, etc., facilitate the removal of odors. We first dispose of the source of the odor, but this is difficult if we have walls saturated with odors as sources. Results might be obtained in this case by driving the odors out of the walls, by increasing the temperature and distilling them out and then treating the free odors with ozone.

---

[*] A lecture held at the Ninth Congress for Heating and Ventilating at Cologne, 1913 Translated in abstract by Dr. M W. Franklin.

*Hiding or Covering of Odors.*—In effective concentrations ozone can destroy certain odors through oxidation, as we can prove beyond a doubt for hydrogen sulphide, indole, skatole and decayed matter. If the odor appears after the ozone is removed the after-odor is due to the residues of the odors absorbed by the walls, carpets, furniture, upholstery, etc., and which were protected from the ozone by their depth. Of great importance for the explanation of after-odors are the experiments of Lehman and Kisskalt as to the absorption of scents. When Kisskalt brought dry ammonia vapor into a room so much was absorbed that even after two to three weeks several grams per day passed back into the air.

*Tests to Remove Odors with Ozone.*—Hill and Flack found ozone to be powerful in removing odors. They filled their test room with tobacco, ammonia sulphate, carbon disulphide vapors, human excrements or putrefied meat, and they were not able to discover the odor after two minutes of ozonation.

Erlandsen & Schwarz and L. Schwarz had no great success in their tests in large rooms, although the latter states that large quantities of ozone in truth deodorize the room. In general, scents and odorous substances, which are clearly defined chemically and simply constituted, as hydrogen sulphide, sulphur dioxide, ammonia, indole, skatole, iodoform, etc., are destroyed by ozone.

*Ozone and Hydrogen Sulphide.*—Kisskalt found hydrogen sulphide to be decomposed in the air, with ozone in excess. Erlandsen and Schwarz proved that ozone destroys the hydrogen sulphide odor.

*Ozone and Sulphur Dioxide.*—Schwarz and Münchmeyer showed that an excess of ozone would react with at least part of the $SO_2$ and form sulphuric acid.

*Ozone and Indole, Skatole.*—Erlandsen and Schwarz found indole and skatole odors greatly reduced and even absent. Kisskalt treated a room smelling stuffy and damp, and with whitewashed walls, with ozone, 0.37664 mg. per cbm. (= 0.1883 per million), and skatole was evaporated over a gas lamp. He concluded that the skatole odor had been destroyed by the ozone. Schwarz and Münchmeyer in quantitative tests found indole and skatole destroyed in a short time with an excess of ozone. In the control tests there was a strong skatole and indole odor, while with ozone there was an agreeable, etherlike odor.

*Ozone and Merkaptane.*—Schwarz and Münchmeyer found that merkaptane is easily oxidized by ozone.

*Ozone and Trimethylamine.*—Erlandsen and Schwarz could not destroy the trimethylamine odor with ozone, but they evaporated 5 cc. of a 33 per cent aqueous solution in a room with less than 15 cbm. contents.

*Ozone and Butyric Acid.*—The smell of butyric acid was removed after 70 minutes' action of ozone. After an hour the smell returned, however, and was present even on the next day. Kisskalt found that butyric acid vapors in the air had not combined chemically with the ozone after 50 minutes.

*Ozone and Iodoform.*—Tests of Dr. J. Muller in the Nüremberg City Hospital demonstrated that the smell of iodoform is removed by ozone.

*Experiments of Bail.*—Bail found that with ozone in the small quantities possible in ventilation the odor of evaporated decayed matter was strongly affected after removing the source of the smell. The nauseating character of the odor disappeared, leaving behind only a persistent glue odor. He noticed that the ozone smell always appeared later, while the air took on a peculiar "fresh" characteristic. (This coincides with the views of Cramer, Hill and Flack.) The later appearance of the ozone odor indicates that ozone is used for the oxidation of the odorous matter and can appear only after having removed this. The original smell is made of a number of individual odors, some of which oxidize and leave the glue odor behind. They did not reappear after stopping the ozone supply so that they must have been destroyed.

"We may conclude, therefore, that small quantities of ozone, practically used, can destroy certain disagreeable odors in the air, and there is no reason to doubt that the excrements and their odors can be influenced by ozone. Through this fact we could explain the excellent results obtained by Lübert and others with ozone in theatres, halls, etc."

*Ozone and Tobacco Smoke.*—Of greatest interest, on account of its application to restaurants, is the influence of ozone on tobacco. Cramer says: "If we blow ozone into a glass tube filled with tobacco smoke the smoke conglomerates and soon disappears."

Hill and Flack were able to dispose of tobacco smoke through ozone. Erlandsen and Schwarz saw no influence of ozone on very heavy tobacco smoke, though in weaker concentrations the smoke was "covered over" by the ozone. In our own tests with strong ozone concentrations, cigarette smoke was entirely destroyed in a room and could not be perceived after re-entering the room, as there was no after-smell. Tobacco smoke on clothing is disposed of by the ozone. Konrich says that ozone has only a perfuming action, without destroying the smelling substances, but it is impossible to substantiate his opinion in view of the exact tests of Kisskalt and of Schwarz and Münchmeyer.

*Is Ozone Poisonous?*—Much excitement has resulted from the cry that ozone is a poisonous gas. Hill and Flack, as also Konrich, have made a considerable stir in this direction and it is therefore necessary to go more fully into their work. All agree that weaker ozone concentrations have no harmful effect at all, while stronger concentrations produce more or less local irritation of the mucous membranes. Schultz believed that the ozone went directly into the blood and worked secondarily on the lungs. This opinion was disposed of by Bohr and Maar, who showed that the lobe of the lungs influenced by strong ozone became irritated, while the other half, treated with ordinary air, remained normal. Pflüger states that ozone in contact with blood is immediately destroyed. Cramer said at the Frankfurt Congress for Heating and Ventilating: "In earlier times we assigned to ozone a poisonous influence on animal organisms, while recent investigations have shown that the ozone is poisonous only when made chemically and not pure. A mixture of chemically pure ozone with atmospheric air can, if the percentage of ozone is not too concentrated, never hurt an organism, as statements from doctors and scientists show. Only in very concentrated form does it attack the lining of the mucous membrane."

Hill and Flack state that the only action of ozone is that it causes irritation of the lungs if inhaled in strong concentrations for a considerable time, and that the danger signals are well set. These authors report tests with rats, cats, dogs, goats and mice. The animals were placed in airtight glass chambers and the ozone varied between 2 to 40 parts per million. They conclude that animals die when exposed to 15-20 millionths parts for two hours, but this does not coincide with their table wherein a dog and three rats recovered after exposure to this quantity. The causes of death were inflammation of the respiratory tracts, blood congestion in the lungs and edema of the lungs. Microscopically the alveolæ showed inflammatory exudations and hemorrhages. There were no other changes in the body.

There are several objections to these tests. First, it is not certain that their accounts of the ozone concentrations were correct; they determined the ozone in acidic potassium iodide solution (1 per cent), and this gives too high ozone value; also their method of using only 10 liters of air in the determinations is questionable. The judgment of such animal tests as regards the poisonous quality of the ozone is moreover very difficult. There are no figures to show the size of the experimental chamber, the quantities of air passed, nor the circulation. With their tests on odor disposal they placed two ozonators at the ceiling of the experimental chamber, but in the animal tests these points are not mentioned. There are no indications of the capacity of the ozonators. Through all these omissions it is difficult to see whether the disturbances in the animals are due to the ozone alone, or whether other causes like insufficient ventilation, excess of heat and carbon dioxide poisoning are to be added, nor do we know that the authors did not use ozone free from nitric oxides, therefore we cannot regard these proofs very highly. Hill and Flack used enormous concentrations in their animal tests, which by far transcend the quantities ever used in practice, and yet they have not always led to death.

*Animal Tests of Konrich.*—Konrich used a glass chamber 44 cm. long and 20 cm. wide and 18 cm. high, equal to 15,140 ccm., and gives accurate results of his seven tests. The ozone was produced in a grate ozonator and passed into the chambers under special precautions. He used rabbits, guinea pigs, white rats and mice.

There are many objections that can be brought against these experiments. The animals were in a comparatively small space, in some tests too many animals were in the chamber (1 rabbit, 2 guinea pigs and 4 rats); the quantity of air was 13.5 to 73.62 liters per hour, which is very little. The change of air was therefore in one case less than one time per hour; three times, more than twice per hour, and twice, more than two times per hour. Only in the last tests were the changes more than 4.6 times per hour, but in this test the ozone concentration was very high (0.23 gms. per cbm.). These facts give rise to the opinion that they died through other influences than ozone, as $CO_2$ poisoning, excess of heat, etc., a good quantity of the 16 liters of air being used by the animals. It may be that there are other causes, as for example, nitric oxides or nitrous vapors, as seems possible from the appearance of the lungs. My conclusions on this last fact are based on experience I obtained in the poison cases, through nitrous vapors, in Cologne. My suspicions were further confirmed by Von Kupffer, who stated that it is possible for nitrous vapors to have been formed as Konrich did not cool his ozonator grate frequently.

That pure ozone is not dangerous to small animals was proved by Sigmund. Labbé and Oudin call attention to the fact that chemically prepared ozone is always impure and often has constituents like phosphorous acid. When we approach natural conditions in treating animals with a mixture of atmospheric air and ozone we find no harmful effect. Labbé says: "Among the numerous ozonators there are very few that can produce a pure ozone in quantities that have been determined to be correct by tests. Moreover, it is very important to avoid the production of nitrous products as otherwise there will be caused irritations."

*Konrich's Tests with Human Subjects.*—The experimental chamber of glass and wood with air-tight doors has 3.8 sbm. capacity. A grate ozonator and electric ventilator were used. Through special valves the changes could be made so as to stagnate the air, circulate it, ozonize, remove this air and change by fresh air, bring in partly used, partly fresh air; ozonized and circulated air; air removed and then filling the chamber with fresh air. In the chamber there were one or two persons who remained from 40 minutes to 4 hours 35 minutes. In the tests with stronger concentrations the ozone varied between 0.431 and 6.72 mg. per cbm. Through adding steam the air in the chamber could be saturated with moisture. In other tests the air was dried and in some cases heated.

Konrich calls attention to the fact that the tests with people give the same results as those with animals, only that the irritations of the respiratory organs are more in evidence, and he adds that the sensitiveness towards the ozone is very different individually. The mucous membrane seems to be more irritated when the air is dry; when the air is very moist the presence of ozone is less irritating, and it is not as perceptible as an odor. The subjects suffered considerable inconveniences and trouble physically, but it is questionable whether these were due to ozone or to the other causes.

This question, according to my opinion, must be answered negatively. The tests were made in an abnormally small space, usually without air renewal, only the room air being ozonized. That the air in the chamber was vitiated to the highest degree is not surprising, and this is shown by the high increase of carbon dioxide content. We may assume, moreover, that the $CO_2$ at the floor level was even worse; the temperature also was very high (21 to 25 deg. C.); the humidity varied between 60 per cent and 90 per cent. Konrich thought the dry air increased the irritability of the membranes to the ozone, so he humidified the air with steam.

We cannot very well call air of 66 per cent to 68 per cent, or even 60 per cent, relatively dry. Esmarch says that a room with 30 per cent to 60 per cent relative moisture is hygienically proper. The percentages above 60 are therefore high. In test (7) the humidity rises to 80 per cent and then to 100 per cent, then after 12 o'clock 13 per cent to 25 per cent steam is admitted, whereupon the ozone odor is reduced and the burning of the eyes, also the coughing, are decreased.

Why more steam was admitted is not clear, since there was enough moisture without this addition; at this time the temperature was 30 deg. C. at 80 per cent humidity. This is a tropical climate artificially produced, and it caused trouble through excess of heat and the high humidity factor and its influence on respiration and on evaporation from the skin. To this must be added the poisonous effect of the $CO_2$. The calcium chloride drying apparatus was able to reduce the moisture only to 55-66 per cent, which is still too moist; however, the temperature was relatively low (18 to 20.5), while in the other cases it was 25.5 deg. to 29 deg. C.

I am nowise inclined to state that ozone is not harmful when used in very strong concentrations, and that it then could not irritate. We know the intensive action of ozone from water sterilization and we can easily demonstrate its chemical action, but I do not think the phenomena in these tests are pure ozone effects, as there are many other factors that enter. Labbé and Oudin, moreover, noticed in the production of ozone the phenomena of metal vaporizations, and it is well known that metallic vapors have a strongly irritating action and are very poisonous.

*Author's Tests.*—I, personally, made some tests with ozone. Two systems were used, the one in the abbatoir of Mühlhausen, using a large central ozone ventilating plant with water cooling device, the other with two local ozone generators without cooling. Low concentrations were found pleasant whilst stronger concentrations of ozone caused more or less irritations. Several persons claimed that with stronger concentrations they felt tired, faint and had headaches. After longer exposure in the rooms with stronger ozone concentrations they felt, on the next day, physically tired, but in these cases there were used concentrations which could not be used practically even in the worst cases, one test showing 2.7 *grams* ozone and 1 cbm. air. No really serious disturbances were noticed, though several times it was possible to smell an after-odor of ozone absorbed by clothing.

*Results from Practice.*—The preceding results show that there are no valid grounds for considering ozone a poisonous gas and this opinion is strengthened by the results of wide experience and practice. These particular results are all the more important since in them the ozone is not dealt with *milligrams* but in *grams.* It cannot be denied, moreover, that many times workers are exposed to high doses of ozone without being hurt.

Erlwein says: "It is a fact at any rate that there have never been proven cases of sickness of a serious character due to breathing ozone air. Special attention is called to a large water sterilization plant operating for more than ten years, where the working force is constantly moving in an atmosphere which is many times more strongly mixed with ozone than is ever found in actual ozone ventilation installations. There has never been a case where these persons have been on sick leave due to the high ozone concentrations."

*Use of Ozone for Ventilation.*—We come now to the use of ozone in ventilation. The air in closed rooms vitiates:

(1) Through respiration of the lungs, the liberation of carbon dioxide, liberation of water vapor, increase of temperature, perspiration from the skin, liberation of various exhalations, scents, among them probably the fatty acids.

(2) Illumination vitiates the air through increase of temperature, liberation of $CO_2$ and of odors, as petroleum.

(3) The admixture of other odors, as odors of food, tobacco, etc.

In the main we deal with an increase of the humidity, the carbon dioxide percentage, a decrease of oxygen and the vitiation of the air with disagreeable, offensive odors. Especially bad is this in assembly halls, restaurants and steerage decks. This vitiation of air is not only unpleasant but dangerous, and leads to poor breathing and faulty nutrition and digestion. Sensitiveness to odors varies and cannot be taken as a good indicator of bad air, as we get used to the bad air and it is only when we step out into the fresh air and then return that we notice it in the room. The air of uninhabited rooms becomes stuffy and close, due to the exudations of the walls and objects in the room, owing to lack of ventilation.

*Ozone for Ventilation of Human Habitations.*—As we need the oxygen in the air for our life processes, and as we can use the same only in the pure, uncontaminated state from the outside, we must resort to the latter to supply our rooms with fresh air. The only safe method of obtaining this is an efficient ventilation installation, but since it is not always easy to obtain perfect ventilation, ozone has been used in many cases as a very helpful ally, and within a comparatively short time there have been installed a large number of ozone ventilation plants.

We differentiate between: (1) ventilation with ozonized fresh air, and (2) ozonization of the room air. The former is preferable from the hygienic standpoint.

The favorable effect of ozone in cafés, restaurants, theatres and halls has been highly lauded. The ventilation of the subways is also a success. Lübbert has had splendid results with one of the most difficult subjects, the ventilation of emigrant ships. With closed windows the ozonator was able to maintain a tolerable air condition, which, without the apparatus, yas unbearable. Regarding these tests of Lübbert, Konrich states that there were no complaints as to irritations from ozone.

Ozone is also recommended for public baths, which have, in spite of ventilation, a peculiar odor, made up of a number of simpler odors. The exudations of the skin with their fatty acids, the smell of the soap, of the water, of the wet mats, the wet woodwork, the wet walls and objects, all add in bringing about this odor. Kuckuck, in Heidelberg, has succeeded in disposing of this smell with ozone, and the same has been done in Breslau. The bath smell is superseded by that of fresh bleached wash.

Erlwein states that in dissecting rooms it has been possible to decrease the odor of dead bodies considerably.

It is necessary in weaving and textile mills to have a high degree of humidity, which has a very injurious effect on the workers, for with high humidity and temperature, evaporation and radiation from the skin are lessened and the body is unable to cool properly, and there results fatigue and reduced efficiency. Considerations of cost forced certain plants to work in the winter with recirculated air, which of course was partly vitiated, and, although again purified, it was unable to substitute for all the good characteristics of fresh air. Great success was attained when ozone was added to the fresh air.

*Ozone in Industrial Plants.*—A great field for ozone ventilation is open in the food industry, especially in the cold storage chambers of abattoirs. Ozone has caused direct saving in such plants, since the meat remains fresh and good for a longer time. In egg cold storage the ozone has given excellent results in that the disagreeable straw and box odor disappears, fewer eggs decay and the eggs last longer. The manager of the Cologne abattoir says: "Meat that had gone over into partial decay was to a certain degree recovered when the ozonator worked, and the mould coating disappeared."

Konrich reports on an ozonator plant in the Berlin abattoir, in the entrail cleaning room: "In this plant they were proud to state that the complaints of the neighborhood as to the stench from this part of the plant had disappeared. The same plant is also meant by Erlwein in his favorable report on an abattoir. Ventilation, as also an attempt to remove the odor by means of coke filter beds, were failures. The remedy was found when the gases rising through the chimneys were first passed through a duct with concentrated ozone. There is no trace of the former intensive odors. The expensive ventilation was removed and the plant was reported to be in perfect shape by the inspection department."

I might add to this that in the local city there is an abattoir with such a department and that one-half of the same works with ozonator, the other half without. A visit to both sides will easily permit the proper conclusions to be drawn. Konrich reports an ozonator plant in a herring packing establishment, where the success lay in the prevention of mould formation in the store room.

Vetter found that in breweries ozone could be used to purify bottles, barrels, to clean pipe lines and apparatus, after preceding mechanical cleaning. Filter cloths and yeast bags that could not be sterilized by means of steaming and boiling, were sterilized by exposing them for one hour to the ozone.

*Quantity of Ozone.*—The question of ozone concentration is a very important one.

*Lack of Standard Method of Ozone Determination.*—In looking through the literature the author was surprised to see the lack of uniformity in determining ozone quantitatively and found himself unable to draw valid conclusions from different tests or to compare them properly because of the variety of procedures employed.

For quantitative determination the KI method is usually used. A review of the different methods shows that there is no uniform determination. A uniform method is absolutely necessary, for the practical results of an ozone plant depend on proper concentration. A standard method should give detailed directions as to absorption liquid, concentration, reaction, quantity relations, form and size of measuring instruments, manner and length of passage of air, titration, etc. As the creation of such a *standard* method seems to me to be the *first fundamental requirement for scientific and proper advancement in ozone problems,* I would advocate starting a prize contest for the best and most accurate method of ozone determination which can be adopted as standard. A standard method of determination should be so delicate as to detect even the minutest quantity of ozone for whose determination we are at present restricted to the senses which are at best inaccurate. The ideal would be a method which would accomplish this with even a small quantity of air as 10 to 50 liters and give the results in a few minutes.

*When Are We to Ozonize?*—Konrich says: "We cannot answer this question in a general way. If the ozone is sent to the rooms through a central ventilating plant, weak concentrations can be used during the performance in the case of a theatre."

Personally I would like to add to this that we can expect successful results only if we use the ozone ventilation plant frequently, until the walls of the room are saturated with this fresh ozonized air. In inhabitated rooms we can ozonize only in weak concentrations, but with uninhabitated rooms there is no reason why we cannot use stronger concentrations, using them either before or after occupation, or both.

*Value of Ozonization of Air.*—Director Gutman, Stuttgart says: "It is not sufficient by any means, as has often been tried, to send ozone to a room regardless of its distribution, for then we usually have an over-ozonization of some rooms and an under-ozonization of others. This is clear when we recollect that we merely want to purify the air and require, therefore, only a certain quantity of ozone at any one point in the room. To bring in more ozone is useless and in excess cases even disagreeable."

*Conclusion.*—We may sum up all the points considered in the following way:

(1) Ozone is an intensely active gas. Its effect depends on its high power of oxidation. It acts more powerfully wet than dry. Energetic effects are obtained in high concentrations only.

(2) As regards the air purifying properties claimed for the gas we have: (a) We need not count on a destruction of bacteria in the air by ozone, nor their destruction on the walls of rooms, nor on objects in the room. (b) There is no oxidation of the organic dust particles. (c) There is, however, a positive effect on certain scents and the odors given off by the same. Some odors are destroyed, others are weakened. At times we obtain disagreeable mixed odors. After-odors are to be referred back in part at least to the odors absorbed by walls and objects in the room and later diffused outward.

(3) The effects of ozone on man depend on the concentration. In small and weak concentrations the effects are agreeable and are found to be refreshing and entirely without danger. In stronger concentrations the ozone irritates the mucous membranes and especially the respiratory tracts. The sensitiveness differs and is often increased through inflammation of the mucous membrane.

(4) Whether the cases of death in animals and sickening effects in man are due to the ozone alone is a matter of doubt. Care should be taken at least to see that the ozone is pure and has no nitric oxides and nitrous acid.

(5) In ozonization of air we must differentiate between (a) ventilation with ozonized fresh air (best central ventilation); (b) ozonization of enclosed room air. The former is preferable without question, and is the only one that need be considered in the development of the ozone ventilator problem. Ozonization of room air is often only a makeshift of dubious value. Tests with ozonization of room air allow no very valid conclusions which might be applied to the ventilation of rooms using ozonized fresh air.

(6) For ventilation with people in the rooms only the weakest concentrations are to be used, such as lead to no complaints by the people.

(7) Strong concentrations are to be used only when no persons are in the rooms, or in rooms used only for a short time. They are possible for industrial plants (although here temporary high concentrations may be used without danger or permanent injury).

(8) On no account does ozonization permit the curtailing of ventilation. Good ventilation is the first prerequisite. Ventilation can be improved by combining it with ozonization.

(9) With these suppositions and under these conditions, the use of ozone in the air seems not only permissible but even advantageous, especially in industrial operations and plants.

(10) The peculiar contradictions between the favorable practical results and the results of many laboratory experiments should be cleared up by further research.

(11) For this we need in the first place a standard method of ozone determination.

(12) A standard nomenclature for the ozone concentration is also desirable.

---

**Prizes for Highway Study.**—To encourage investigation of methods and materials for road and street construction, and to interest engineering students in highway problems, The Barber Asphalt Paving Company of Philadelphia, Pa., has offered prizes of $100 for the best paper written by a member of the graduating classes of the leading engineering schools. The title suggested is "Asphaltic Materials for Highway Construction." The paper and its conclusions may be based upon service tests and the lessons of experience; the physical qualities or chemistry of asphalt; or it may combine any two of these lines of investigation. The length of the paper is limited to 3,000 words and all manuscripts must be received not later than June 1, 1914. The purpose of this prize offer is to turn the attention of engineering students to street and road construction as a field of work in which there is great need and great opportunity for trained men.

The Bunker Hill & Sullivan Mining Co. is having "moving pictures" made of all its operations in mining and milling. Underground operations will be photographed by the aid of a powerful electric light. The completed pictures will show the treatment of the ore by concentration from crushing to shipment of concentrates. It is reported that the films will be placed at the disposal of mining schools.

## The Iron and Steel Market

The iron and steel markets became more and more quiet during March, until at the close of the month a state bordering on stagnation was reached. Strictly new buying became almost nil, and by the middle of the month specifications on contracts had dropped to 50 or 60 per cent of the rate obtaining in February.

The rate of steel production has not been decreased as a result of the smaller flow of shipping orders, and remains, as an average of the whole industry, at between 70 and 75 per cent of capacity, but there is no question that production will very soon have to be curtailed if demand does not improve. In some lines the mills have orders on books sufficient to enable them to maintain the pace of production for a month or longer, and the tin plate mills are still more strongly fortified, but in some lines a curtailment in output early in April is rather probable.

The steel trade has been at a loss to account for the loss in market activity in March. The lull in new buying which developed in February was expected, after the fairly heavy January buying, but a decisive improvement was fully expected before the close of March in anticipation of spring and the resumption of outdoor work on a large scale. A part of the quietness has been attributed to general timidity in business circles on account of legislative uncertainties at Washington in connection with the anti-trust bills, while a part is ascribed to a waiting attitude on the part of the railroads, due to the pendency of their demand before the Interstate Commerce Commission for an advance in freight rates. While these theories early found general acceptance, it has since become evident that some other influence must also be at work, for even in the midst of these conditions there should be more buying than has occurred during the second half of March, and there is reason to suspect that this other influence is that many buyers have adopted a theory that steel prices are going to be lower before they are higher. There are some good grounds for such a theory. Prices were advanced rather generally at the beginning of February, on the basis of the buying which had occurred in January, and to support such advances further good buying would naturally be required, and such buying has not occurred. In addition there is the condition that many contracts were written for the second quarter at $1 a ton advance over first quarter prices. To make such contracts enforcible the general market would have to advance, and when it does not the result is that the business will have to be written over again. With a fresh period of competition for this business the whole price question would be reopened.

While steel prices did not definitely decline in March to any extent, there was softening in the case of several products, and plates and shapes became quotable at $1 a ton lower than at the close of February.

### Pig Iron

The market has become extremely quiet in all districts. In some cases furnaces have attempted to advance prices, but the advanced quotations must be recognized as purely nominal, since buyers evince no tendency to take hold. Indeed, there is the development that shipments against contracts are in some cases not being taken at the full rate. A few merchant furnaces are understood to be considering the question of blowing out in the near future, as soon as enough iron has been accumulated to take care of contracts now on books. Inasmuch as the merchant furnaces as a whole have not increased their production since the first of the year, while the steel interests have largely increased their pig-iron output, the country's requirements in merchant pig iron must be quite limited. The market stands quotable as follows: No. 2 foundry, f.o.b. Birmingham, $10.75; No. 2 foundry, delivered Philadelphia, $15 to $15.25; No. 2 foundry, f.o.b. furnace, Buffalo, $13.25 to $13.75; No. 2 foundry, delivered Cleveland, $13.75; No. 2 foundry, f.o.b. Chicago furnaces, $14.25; at Valley furnaces (90 cents higher delivered Pittsburgh), Bessemer, $14.25; basic, $13; No. 2 foundry and malleable, $13.25; gray forge, $12.75. Ferromanganese is nominally quoted at $39, Baltimore, but the price on both prompt and contract can usually be cut to $38.

### Steel

The market in billets and sheet bars has been practically stagnant. When the mills advanced prices about the beginning of February their new quoting level was $21 for first quarter delivery and $22 for second quarter delivery on billets, with $1 extra for sheet bars. Thus the market should really advance $1 a ton on April 1, but conditions in the general trade hardly support an advance at this time. The sheet mills are indisposed to pay an advance as their market has tended to weakness rather than to strength during March. There has been no important inquiry to test the quotation for second quarter. Rods are $26 to $27, Pittsburgh.

### Finished Steel

Prices named below are f.o.b. Pittsburgh, unless otherwise stated:

Rails, standard sections, 1.25c. for Bessemer, 1.34c. for open-hearth, f.o.b. mill, except Colorado.

Plates, tank quality, 1.15c. to 1.20c.

Shapes, 1.20c. to 1.25c.

Steel bars, 1.20c., base.

Iron bars, 1.35c., Pittsburgh; 1.27½c. to 1.32½c., Philadelphia; 1.15c. to 1.17½c., Chicago.

Wire nails, $1.60 per keg, base; plain wire, 1.40c., base.

Sheets, blue annealed, 10 gage, 1.40c.; black, 28 gage, 1.95c.; galvanized, 28 gage, 2.95c.; painted corrugated, 28 gage, 2.15c.; galvanized corrugated, 28 gage, 3.00c.

Merchant steel pipe, ¾ to 3 in., 79½ per cent off list.

Steel boiler tubes, 3½ to 4½ in., 71 per cent off list.

Standard railroad spikes, 1.45c., Pittsburgh; 1.50c., Chicago.

Structural rivets, 1.70c.; boiler rivets, 1.80c.

Cold rolled shafting, 64 per cent off list.

---

## The Non-Ferrous Metal Market

Dullness characterized the non-ferrous metal markets during March. Buyers held aloof generally, seeming to be well covered for immediate needs. Prices quoted were not adhered to strictly, and producers were willing to make concessions to get business. On account of the accumulation of stocks, producers have exerted some pressure to sell.

Copper.—Business in Lake copper is in the hands of but one or two producers, and they continue to get their asking price. Quotations are nominal, however, as the same conditions prevail that have obtained for some months past. Considerable business has been done in electrolytic, but at reduced prices. Domestic consumption has exceeded foreign. Electrolytic now stands at about 14.07.

Tin.—An almost entire absence of demand characterizes this market, and consumers are apparently well supplied. The prices are low and conditions are favorable for a buying movement. March tin is quoted at 37½ cents.

Lead.—The American Smelting & Refining Co. continues to ask 4 cents for lead, which is the New York quotation. Business at St. Louis has been done at 3.90 cents, and quotations are given as 3.87½ to 3.92½ cents.

**Spelter.**—Prices are lower and a larger tonnage is reported sold. It has been supposed that accumulation of stocks in smelters' hands has caused them to reduce the price to a point that would attract business. St. Louis quotations are 5.10 to 5.12½ cents, and New York 5.25 to 5.27½ cents.

**Other Metals.**—The market for aluminium continues dull, with only moderate sales. No. 1 ingots are quoted at 18½ to 19 cents per pound, New York. Only a fair demand exists for antimony, and quotations vary from 6 to 7.35 cents for various brands. Business is good in quicksilver. The New York quotation is $39 per flask of 75 lb. San Francisco price is $38.50 per flask for domestic orders.

## Recent Chemical and Metallurgical Patents

### Gold and Silver

**Slime Filter.**—That all the possible modifications of continuous vacuum filters have not yet been considered is shown by the patent granted to Mr. James Drage, of Boulder, Western Australia. A four-stage machine is shown in longitudinal section in Fig. 1, and in transverse section in Fig. 2, the latter being on the line *ab* of Fig. 1. The object of the machine is to provide a series of filters, each with its agitating and filtering tank, for the successive washing of an ore pulp with several solutions or water washes. The filtering units proper are arranged in an annular ring around the periphery of a wheel. Each of the units is connected with sources of vacuum and pressure, so that as the wheel revolves the filter units that are submerged in slime pulp will be under pressure, thereby removing the liquid and forming a cake of solid on the filter fabric; on emerging from the pulp the units come under pressure so that the cake is discharged. Suitable means are provided to direct the discharged cake into the mixing and agitating tank of the next filter, where the same operation takes place, and so on through the four stages.

Referring to the cuts, the filter wheel is represented by 3, and the filtering units by 17. Pipes from each unit to the central valve connecting with vacuum and pressure are shown at 14. From left to right, each filter has an agitating tank with agitator 25, wherein the pulp is kept at a uniform consistency. Perforated partitions 23 are placed between the agitating tanks and the filtering-tanks, as shown in Fig. 2. The pulp flows freely from the agitating to the filtering tank through perforations as shown. The filtered and washed pulp is discharged from the machine at 36, after having received several treatments. (1,087,647, Feb. 17, 1914.)

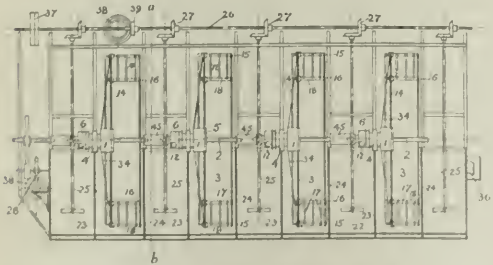


FIG. 1—FOUR-STAGE VACUUM FILTER

### Copper

**Hydrometallurgical Process.**—Mr. Edward R. Weidlein, of Pittsburgh, Pa., has invented a process for the recovery of copper in the wet way, based generally on the reversible reaction

$$CuSO_4 + SO_2 + 2H_2O = Cu + 2H_2SO_4.$$

The mode of operation is said to make this reaction of great commercial importance, because copper can be precipitated from its solution substantially quantitatively in metallic form. Ore is leached with a solution containing 3.6 per cent sulphuric acid, whereby copper is taken into solution and the free acid content is reduced to less than 1 per cent. The free acid is neutralized by lime or other base, and the precipitate of calcium sulphate removed by filtration or otherwise. The copper sulphate solution, containing say 1.5 per cent copper, is then treated in a tower, for example, with sulphur dioxide gas, until the concentration of the latter in the solution is the same as that of copper, viz., 1.5 per cent. The solution is then led to preciptating tanks where it is heated to a temperature of 150 deg. C., giving a pressure of 100 lb. per square inch. Under these conditions of temperature and pressure, copper is precipitated in finely divided form, and can be removed by filtration. It will be noted that sulphuric acid is regenerated in the reaction, and the solution can be used for further leaching. Iron will not be precipitated under the conditions given. Ferric salts in solution will be reduced to the ferrous state, becoming solvents for copper. (1,089,096, Mar. 3, 1914.)

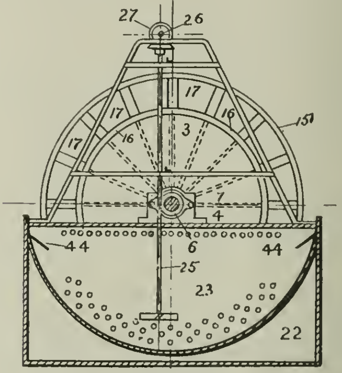


FIG. 2—SECTION OF FOUR-STAGE VACUUM FILTER

### Rare Elements

**Reduction of Rare Elements from their Oxides.**—Processes usually used for the reduction of zirconium, thorium, titanium, cerium, vanadium, uranium, tungsten and molybdenum, have been based on a reaction between sodium and chlorides of the metals mentioned. Direct reduction from their oxides was disadvantageous because the alkaline metals distilled at the high temperatures employed. According to a patented invention of Mr. Hans Kuzel, of Baden, near Vienna, Austria-Hungary, and Edgar Wedekind, of Strassburg, Germany, the direct reduction of these metals from their oxides can be accomplished by treatment with metallic calcium at high temperatures, say 800 deg. C., or more.

Thus, in the production of pure zirconium, 50 grams of its oxide is intimately mixed with 72 grams of metallic calcium, and the mixture is heated in a metallic bomb under vacuum. The reaction proceeds rapidly. On completion, the bomb is cooled and then opened in an atmosphere preferably free from oxygen and nitrogen. The mass is treated with water and then dilute acid to bring all calcium into solution. The insoluble residue is filtered and dried, preferably in a vacuum, at a temperature of 300 deg. or 400 deg. C. The product will be 96 per cent zirconium, about 3 per cent zirconium oxide and other impurities. The properties of the element thus prepared differ from those announced heretofore, and the inventors ascribe the difference to the fact that former investigators have not produced pure zirconium. (1,088,909, Mar. 3, 1914.)

**Extracting Thoria from Monazite Sand.**—The production of thoria in such condition as to be available for use in the preparation of the Welsbach mantle, is the object of a process patented by **Mr. Charles Baskerville**, of New York City. The general composition of monazite is given in round numbers as follows:

| | |
|---|---|
| $P_2O$ | 29.0 per cent. |
| $Ce_2O_3$(earths) | 31.0 " " |
| $Di_2O_3$(earths) | 31.0 " " |
| $SiO_2$ | 1.5 " " |
| $ThO_2$ | 6.5 " " |

The invention contemplates the reduction and volatilization of the phosphorus, and the simultaneous production of a silicon compound that is volatile at the temperature employed. There is the further object of incorporating in the mixture such elements as will permit the ready disintegration of the furnace product, when treated with water, thereby avoiding the necessity of expensive and difficult fine grinding.

For these purposes the inventor uses carbon and calcium fluoride, which, when fused with monazite sand in an electric furnace, will reduce and volatilize the phosphorus and form silicon tetrafluoride which also is volatile. Further, the furnace mixture can be so compounded with lime that the production of calcium carbide will be formed throughout the mass, and when the latter is treated with water it disintegrates, yielding a product finely divided and not requiring expensive grinding. The furnace charge may be compounded thus:

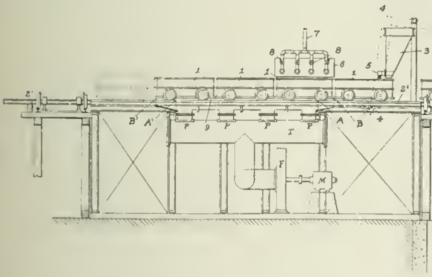


FIG. 3—SINTERING MACHINE

| | Pounds |
|---|---|
| Monazite sand | 1.0 |
| Carbon (petroleum coke) | 1.1 |
| Quick-lime | 0.8 |
| Calcium fluoride | 0.15 |

Various types of electric furnace have been used in producing the thoria, and both direct and alternating current can be employed of different voltages and amperages. The inventor prefers, however, to use a crucible furnace, also alternating current varying in amperage from 100 to 300 amperes and in voltage from 25 to 60 volts.

After the furnace product has been disintegrated by water, the lime is removed by decantation, and the residue is treated with acid to obtain a solution from which thoria can be extracted. (1,087,099, Feb. 17, 1914.)

### Ore-Sintering Apparatus

**A form of apparatus** for sintering finely divided ores and similar materials, recently patented by Mr. **Albert F. Plock**, of Pittsburgh, Pa., is shown diagrammatically in Fig. 3. In general, the process bears similarity to that of Dwight & Lloyd, wherein a comparatively thin bed of material is ignited and sintered while being passed over a receptacle from which air is being exhausted, thereby forcing a down draft through the bed of ore. Referring to the figure, cars 1, equipped with herringbone grates, receive a charge of material from the hopper 3, pass under the igniter 6, and across the air tank T. A motor M operates a fan F which exhausts the tank T, and thereby draws a current of air downward through the ore bed on the cars. The apparatus is designed to permit either continuous or intermittent operation, in accordance with the character and requirements of the charge; to permit the removal of the ore-carrying units to any distance from the sintering machine and to provide units which can be handled in any special manner desired. Each car has its own separate air chamber 14, as shown in Fig. 4 which illustrates a vertical cross section of the apparatus through the ignition hood. Fig. 2 also shows the manner of connecting the air chamber of the car with the chamber T that connects with the exhaust fan. This form of connection may be modified by placing it at one side of the car, or it may lead from the bottom of the car outside the wheels instead of between them. (1,089,153, Mar. 3. 1914.)

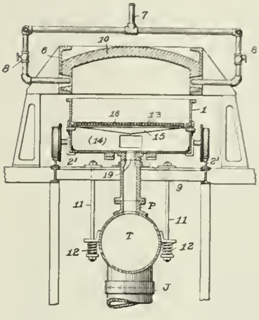


FIG. 4—SINTERING MACHINE

**Another form of sintering apparatus** is that of Mr. John E. Greenawalt, of Denver, Col., shown in Fig. 5. It consists, in brief, of a sintering pan 1 adapted to turn on hollow trunnions 5. It is provided with a grate G on which a charge of ore is placed. The ignition apparatus is run over the pan, and the ignition of the charge is effected from two burners B of special construction. The ignition apparatus consists of a

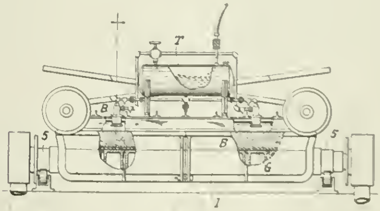


FIG. 5—SINTERING APPARATUS

tank T of oil fuel, with suitable connections to a source of compressed air, on the one hand, and with the burners on the other. The roof of the ignition hood is perforated to permit a down-draft current of air to be drawn into a combustion chamber, through the ore and out by way of the trunnions. In such an apparatus, the uniform ignition of the areal surface of the charge is an important point, and in order to provide for this, a special form of burner is used, shown in Fig. 6, by means of which a horizontal blanket of flame is projected over the entire surface of ore. The burner consists of two parts, *a* and *b*, bolted together. Between the two parts is placed a metal disk with radial slots, as shown at S. Oil is injected through a Schutte-Koerting spray-nozzle 24, and air enters tangentially at 25. The mixture strikes the cone 19 and is diverted horizontally through the radial slots of the metal disk, and spreads equally over the surface of the charge, forming a sheet of inflammable particles which, when ignited, produces a blanket of flame igniting instantaneously the entire surface of the charge. The projection of the horizontal streams of fuel is under sufficient head to suffer no material deflection by the downdraft current of air passing through the charge. (1,088,818, Mar. 3, 1914.)

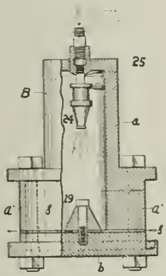


FIG. 6—BURNER FOR SINTERING APPARATUS

### Briquetting

**The preliminary treatment** of mineral and metallic substances which are to be united by pressure is the subject of a patent granted to **Arpad Ronay**, of Berlin, Germany. "The essential feature of this invention is that hot steam shall be introduced into the mass of particles to be pressed, at that period of time which precedes the pressing operation." The process may be applied to the briquetting of flue dust, ores, coal dust, metal filings or shavings and combination of such materials. The use of steam permits the displacement of air in the mass, and also introduces a small quantity of water which is of advantage. The desirable oxidation of the particles is brought about uniformly and quickly at the high temperature of the operation.

It is essential that steam, as such, exists in the mass at the time of briquetting. (1,087,183, Feb. 17, 1914.)

## Synopsis of Recent Chemical and Metallurgical Literature

### The Work of Crushing

In a mathematical discussion of the work done in crushing rock and ore, and the methods of finding the mechanical efficiencies of crushing machines, Mr. **Arthur F. Taggart** concludes that Kick's law is correct and that the so-called law of Rittinger is inapplicable.

The discussion appears in the January issue of the "Bulletin" of the American Institute of Mining Engineers. According to the author the reason why different investigators have arrived at different conclusions regarding the power consumed in crushing and the efficiencies of different machines, is that the tests are based on different assumptions. Some assume the correctness of Rittinger's law, that the work of crushing is proportional to the reduction in diameter or to the new area produced, while others base their work on Kick's law, which states that the work of crushing is proportional to the volumes produced. After analyzing the proofs of various experimenters, the author comes to the conclusion that Kick's law is correct wthin the limits of experimental error.

"Attempts to prove the work of crushing proportional to the reduction in diameter err in one of the following ways:

"1. By neglecting the distance quantity in the work formula.

"2. By assuming that particles in a crushing machine are acted upon in such a way as to produce simple shearing stresses.

"3. By assuming that the force exerted is a constant.

"4. By confusing 'force' and 'work.'

"The difference in the results obtained according to the two assumptions is small throughout a considerable range of sizes. The difference is marked in the fine sizes, where the greatest amount of power is wasted."

**Tin Concentration at the Geevor Mill, Cornwall.**—The Cornish practice in tin dressing has frequently come in for more or less criticism from those who consider the methods inefficient and not in accord with modern ideas. On the other hand Cornish operators are likely to feel that much of the criticism comes from men unfamiliar with local conditions, and therefore unqualified to speak with authority. *Bulletin No.* 110, Inst. of Min. & Met., contains the record of an application of modern ideas of ore dressing at the Geevor tin mill, written by Mr. Horace G. Nichols. *Bulletin No.* 111 contains the extended discussion aroused by Mr. Nichols' paper.

It appears that the Geevor mill was remodeled under the technical direction and responsiblity of Mr. R. Gilman Brown, and that Mr. Nichols was Mr. Brown's representative in the matter of starting the mill and gathering technical results. Unfortunately, and for reasons that do not appear fully in the discussion, the remodeled mill was unsatisfactory to the directors of the company, and it was changed back to conform with the method adopted at Dolcoath. This led Mr. Nichols to make public record of the performance of the remodeled mill in order to justify the methods adopted as compared with those in vogue before the change.

The principal feature of the remodeled mill is an attempt to introduce the principles of stage crushing, classification and concentration; adapting the crushing to the requirements of the ore, removing coarse mineral as soon as possible, and regrinding only such parts of the pulp as needed further treatment. The introduction of the Hardinge mill, Richards-Janney classifier and Deister table were "modern" features of the new mill. The use of vanners as coarse concentrators will appear strange and unusual to some, but these machines were in the old mill, and it was desired to use them as far as possible. The difficulty of remodeling an old mill to conform exactly with one's ideas will be readily appreciated by all engineers.

Mr. Nichols states that the recovery under the old practice was only about 40 per cent, and that the tailing contained 19 lb. "black tin" (about 2/3 metal) per ton. He admitted that a higher recovery, possibly 60 per cent, could be made under former conditions, but only by production of a low-grade concentrate. With the new system of treatment the yield was over 75 per cent.

The final treatment, arrived at by much testing, was as follows: From the stamps, which delivered a pulp containing about 35 per cent + 80 mesh material, the ore flowed to a 3-compartment Richards-Janney classifier. The first spigot product, representing +80 mesh pulp, flowed to a Hardinge mill for regrinding; the second and third spigot products were treated on two sets of vanners, three machines in each set. The first set of vanners had a belt travel of 3 ft. per min., and were dropped 5¼ in. at the tail end; the second set had a belt speed of 2½ ft. per min., and a tail drop of 4½ in. The overflow from the classifier was thickened in Callow cones, the thick product being treated on vanners which were run as nearly level as possible and speeded so as to obtain a not too clean concentrate. The tailings from the first two sets of vanners were reground in grinding pans and combined with the tailing from the third set. This pulp was then again classified in a 2-compartment classifier and concentrated on Deister tables. The finest pulp was ultimately thickened and treated on Deister slime concentrators.

The feed to the tube mill contained 62 per cent solids. This thick feed was regarded by the author as an essential requirement for regrinding tin ore. In concentrating with and without the use of a tube mill for regrinding a part of the ore, in the latter case depending on the stamps to grind the whole product fine enough, the percentages of extraction were respectively 78.5 and 69.5. Cone dewaterers were used over grinding pans, thereby eliminating much water and pulp finer than 120 mesh, and increasing the solids in the pan feed from 23 per cent. to 42 per cent. The author concludes from the results obtained that the principles of concentration adopted in treating other ores are equally applicable in tin ores.

### Gold and Silver

**The Cyanide Process.**—A chemical and historical review of the metallurgical process which to-day holds first place as a means of recovering gold and silver from their ores is given by Mr. C. A. Mulholland in the Australian Mining Standard, Jan. 8, 15 and 22, 1914. Concerning the theory of the dissolution of gold in a cyanide solution, the author affirms that gold goes into solution in an indirect fashion, to form gold-potassium cyanide.

"Chemical energy is electrical energy. This dissolution of metals and their compounds and all reactions in solution take place by an interchange of electrical charges which are inherent in all kinds of matter. In a solution whose equilibrium is balanced the atoms and molecules with their definite electrical charges are also in equilibrium. Atoms or molecules going into solution—becoming ions—receive an electrical charge or become ionized, and as soon as they are caused to give up their charges they cease to be ions and separate out of the solution in the neutral or molecular state. In order that a metal can enter into solution it must be capable of withdrawing the charges for its own ions from those of others—for instance, from hydrogen or other metallic ions already present in the solution and the ion from which a charge has been taken separates in the neutral state. Applying this to the particular case of gold entering into a solution of cyanide its modus solvendi may be briefly described as follows:

"The electrolytic pressure of gold in presence of a cyanide solution (that is the difference between its solution pressure and the osmotic pressure of the ions in solution) is just sufficient to enable it to take up an ionising charge of low value from the potassium ions in solution to form an aurous ion which unites with hydroxyl to form a hydrate or more probably hydrated peroxide, which is readily soluble in potassium cyanide.

"The efficient initial cause of the dissolution of gold in a cyanide solution appears to be an electrochemical one, involving, primarily, the elements gold and oxygen. The slight apparent solubility of gold in cyanogen, cyanogen bromide and similar compounds is due to a similar cause and not to the nascent cyanogen molecule."

Another important contributing cause is the phenomenon of catalysis. Among catalytic substances acting in the cyanide process are the silica and ferric oxide invariably associated with the ore under treatment.

A third contributing cause of dissolution is the state of dilution of the solution. When the dissociation of potassium cyanide in any solution has the greatest concentration of ions in unit volume, this point corresponds, within certain limits, with the solvent power of the solution.

"A fourth contributing cause is the property possessed by potassium cyanide of dissolving with tne absorption of heat, so that the dissociation presure increases with the increae of temperature, within certain limits. This property influences the whole process by which substances enter the solution and determines their order and the direction of displacement of the equilibrium of the reacting bodies, however numerous they may be. The temperature, therefore, of the cyanide solution is another contributing factor in the dissolution of gold and other metals."

The author applies these considerations to the reactions occurring in the cyanide and bromocyanide processes, and concludes with a historical review of the patents.

---

## Notes on Chemistry and Metallurgy in Great Britain

*(From Our Special Correspondent.)*

### Rail Steels for Electric Railways

At a meeting of the Institution of Civil Engineers on February 24th Mr. **Wm. Willox** read a paper in which he described the results of tests which he had made bearing on the reduction of the life of rails in tunnels from an average of about five years to an average of rather less than three years, and in some places below one year, on the electrified section of the Metropolitan Railway.

The tests were mainly confined to the curve between Aldersgate and Farringdon Street, and were made with a great variety of steel rails. The traffic at this particular part of the line is exceptionally heavy and at busy times in the morning and evening there are more than 40 trains running in the hour on one line.

The author's investigation has been of an extensive character, and included chemical analyses, tensile tests, tup tests, and impressions of all the rails experimented upon as well as the etching of a large number of sections of the rails. In addition to the results of these tests the results obtained with various steels, including manganese steel, for actual wear at points and crossings are given.

The author points out the necessity for railways keeping their expenditure on permanent ways within a reasonable figure, especially when only about three hours can be devoted to the work of putting down fresh rails, which must necessarily be done after midnight and before the resumption of traffic in the morning.

In giving the good results obtained with manganese steel points and crossings on the curve mentioned, the author points out that, as far as he knows, the use of manganese steel in England, even at crossings, has hitherto been very restricted, and that therefore these results may possess some value. Summing up the results obtained the author has arrived at the conclusion that the rails which have proved the best and most economical are of high-silicon steel manufactured under careful supervision by the process introduced by the late Mr. C. P. Sandberg from basic open-hearth, basic Bessemer and acid Bessemer steels.

### The Effect of Alternating Currents on Primary Cells

At the mid-February meeting of the Royal Society Mr. **S. G. Brown** presented a very interesting paper on the effects produced by the passage of alternating currents of various frequencies up to a maximum of 20,000 through simple voltaic cells. The passage of an alternating current through any such cell appears to prevent entirely polarization, and as a consequence the chemical action becomes very much greater, and therefore the cells yield a much greater quantity of continuous current than they would normally supply.

When the surface of the zinc anode is relatively small the passage of an alternating current stimulates the chemical action between the electrolyte and the anode, and this causes a considerable increase in the current given out. Such increase is dependent in extent on the density of the alternating current, and the experiments described by the author go to show, if not to prove, that when the density is great enough the chemical action may be so intensified as to cause oxidation of any known metal used as the anode.

### The Carbonization of Coal

Dr. **John Harger** recently read a paper before the Liverpool section of the Society of Chemical Industry in which he dealt with the chemical nature of coal and the products of its carbonization.

He said that the researches of many able workers for about a century had not resulted in the acquisition of any definite knowledge of the chemical composition of the substances of which coal was composed, and that with regard to 98 per cent of its constituents it was only possible to guess at their chemical composition. Some coals yielded 40 per cent of soluble matter to pyridine, and although part of this dissolved substance was soluble in chloroform yet it cannot be directly obtained from coal by treatment with chloroform; and this went to show that that portion of the pyridine extract which was soluble in chloroform did not exist in that form in the coal itself, but was formed by the action of the pyridine on some original constituent of the coal.

The government chemists as Eskmeals considered that the inflammability of any given coal is determined by the proportion soluble in pyridine, but he considered that that view was open to question.

The author reviewed the controversy between Dr. Wheeler and Professor Lewes concerning the processes of decomposition which occur when coal is heated, and he supported Professor Lewes in the view that the decomposition at the higher temperatures consists in a splitting up of pitch-like matters formed earlier at a lower temperature. In support of this he showed that at a temperature of about 270 degs. C. ordinary bituminous coal underwent a change not readily noticeable.

With regard to gas-works practice the author considered that modern methods should be revised, because he was of opinion that the existing practice of high temperature distillation is more suitable for the conditions of bygone times, and that the old method of working at lower temperatures was more suitable to modern requirements, such as a yield of light petroleum and smokeless fuel for ordinary consumption.

### Rail Corrugation

At the meeting of the Institution of Civil Engineers on the 24th of February Mr. **S. P. W. D. Sellon** read a paper on "Rail Corrugation and its Causes."

He came to the conclusion that the "crests" are simply cold-rolled whilst the surfaces in the hollows are crushed by vertical loads, consequent on the oscillations of the wheels, above the elastic compressive limit of the steel; but he did not discuss the cause of the oscillatory character of the load. At ordinary speeds the pitch of the corrugations on tram rails corresponds with a frequency of about 100 per second.

The author was quite confident as to the means of prevention afforded by hard steel. He said that between 1898 and 1903 he was responsible for the purchase of 10,000 tons of tram rails with a specified carbon content of not less than 0.6 per cent which had been laid in various towns in England and had not exhibited any corrugation; but where the same tramways had been extended with rails complying with the British standard specifications and containing from 0.4 to 0.55 per cent. carbon corrugation had occurred on such extensions with the same rolling stock and the same method of construction.

### Market Prices

February, 1914.

| | £ s. d. |
|---|---|
| Aluminium ingots, ton lots | 86. 0. 0 |
| Alum, lump loose, ton | 5.10. 0 |
| Antimony, Star Regulus, ton | 28. 0. 0 |
| Borax, British refined crystal, cwt | 18. 6 |
| Copper Sulphate, ton | 22.10. 0 |
| Caustic Soda, 70%, ton | 10. 5. 0 |
| Copper Ore, 10 to 25%, unit | 11/3 to 11. 9 |
| Ebonite Rod, lb. | 4. 6 |
| Hydrochloric acid, cwt | 5. 0 |
| India-rubber, Para, fine, lb. | 3. 0 |
| Mica, in original cases, medium | 3/6 to 6. 0 |
| Petroleum, Russian spot, gal. | 9¼ |
| Quicksilver (Spanish), bottle | 7.10. 0 |
| Sal-Ammoniac, cwt | 2. 2. 0 |
| Sulphate of Ammonia, ton | 12.12. 6 |
| Sulphur, recovered, ton | 5.10. 0 |
| Shellac, cwt. | 3.14. 0 |
| Platinum, oz., nominal | 9. 5. 0 |
| Tin Ore, 70%, ton | 113 to 115. 0. 0 |
| Zinc, Vielle, Montagne | 25.12. 6 |

### Differences

| *Higher* | | *Lower* | |
|---|---|---|---|
| Copper ore, unit | 3 | Aluminium (ton) | 4. 0. 0 |
| Sulphate of Ammonia (ton) | 2. 6 | India Rubber (lb.) | 2½ |
| Tin Ore, ton | 10. 0. 0 | Shellac, cwt. | 8. 0 |
| Zinc, ton | 12. 6 | Copper, ton | 1.12. 6 |
| | | Tin, ton | 4.10. 0 |
| | | Lead, ton | 10. 0 |

Copper opened £66, was £66.17.6 on the 4th, then declined to £65 on the 9th. It was a little higher on the 10th and 11th but again reached £65 on the 13th, and, after a slight recovery, £64.10.0 on the 18th, and has held about that price, closing at £64.7.6.

Tin opened £182 and rose till £187.10.0. was reached on the 4th: it then fell off, being £185 1/8 on the 9th, and £183.12.6 on the 12th; £183 on the 16th and £181 on the 17th, with fluctuations, the tendency has been generally lower, showing £175.15.0 on the 23rd and closes £175.10.0.

**Haematite** opened 61/- and has not varied throughout the month, closing the same.

**Scotch Pig** opened 56/, and was up to 57/9 by the 5th, keeping fairly strong till the 16th, when it was 57/: on the 17th, 18th and 23rd it was 56/9 and closes 56/6.

**Cleveland** opened 50/7½ and rose, reaching 51/9 by the 5th, and was fairly strong till the 13th, when it was 51/1½: it has since had a lower tendency, being 50/9 on the 18th and 23rd, and closes 50/6.

Lead opened £19.10.0, and rose to £20.10.0 on the 3rd: by the 9th it had fallen to £19.15.0 and remained there till the 11th, when £19.17.6 was reached, which has been maintained, closing price being £20.

# Coal-Gas Plant and Lime Plant at the Niagara Works of the American Cyanamid Company

The production of calcium cyanamid represents one solution of the problem of the fixation of atmospheric nitrogen, that is, of the problem to transform the inert and useless elemental nitrogen in atmospheric air into some useful compound.

The calcium cyanamid industry is the result of the experiments of Drs. Frank and Caro, who wanted to produce calcium cyanid from calcium carbide and nitrogen by a reaction analogous to that by which barium cyanid is formed from barium carbide and nitrogen. Their experiments showed, however, that in the cost of calcium the reaction is a different one since the calcium cyanamid instead of cyanid is formed. The inventors, however, found at the same time that the calcium cyanamid—which they had not originally intended to produce—was nevertheless a very valuable product as it can be used almost directly in the form produced as a fertilizer and may also be employed as a starting material for the production of other chemicals.

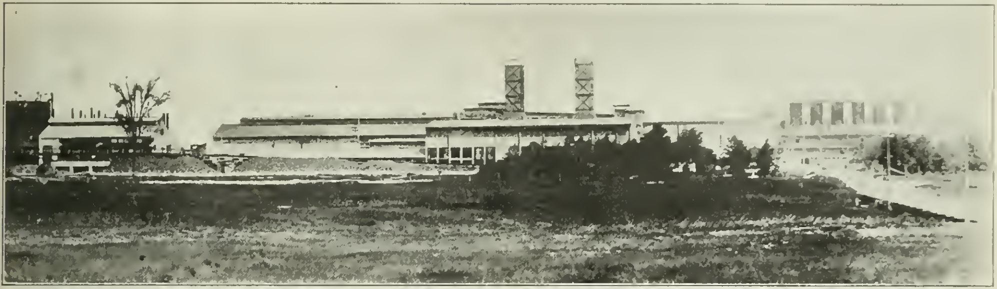


FIG. 1—AMERICAN CYANAMID COMPANY'S WORKS AT NIAGARA FALLS
(Lime plant at the extreme right and coal gas plant at the extreme left)

In the last ten years the production of calcium cyanamid has become a big industry. Its history has been given in the columns of this journal. Reference may be had to former articles published in our volume I, page 423; vol. II, p. 204; vol. III, p. 28, 79, 117; vol. IV, p. 136, 188, 327; vol. V, p. 59, 72, 77, 98, 198, 289, 374, 464, 465, 479; Vol. VI, p. 139, 339, 341, 506; Vol. VII, p. 212, 305, 309, 360; vol. VIII, p. 47, 287, 539, 548, 589, 617, 682, 692; vol. IX, p. 12, 21, 100, 123, 476, 545; vol. X, p. 550, 551, 667; vol. XI, p. 438, 476.

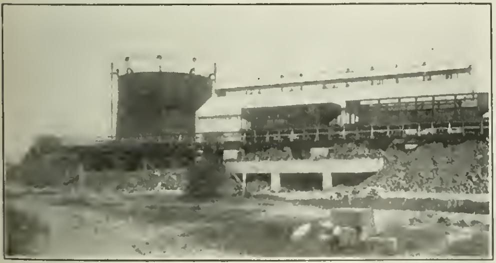


FIG. 2—RETORT HOUSE AND COAL-HANDLING ARRANGEMENT FOR THE RETORT HOUSE

In the last ten years cyanamid factories have been established all over the world. One of the largest is located at Niagara Falls, Ont., Canada, where electric power can be obtained at a sufficiently low rate.

The American Cyanamid Company owns the sole right to manufacture and sell cyanamid in America. Its factories at Niagara Falls began operations on January 1st, 1910. The original output was 12,000 tons a year, but this was increased during 1912 to approximately 32,000 tons a year, and further extensions are under way to give a yearly output of 64,000 tons.

From the very commencement of operations at Niagara Falls it was clear that a plant capable of producing 12,000 tons per year was totally unable to meet the market requirements, but the directors of the American Cyanamid Company adopted the policy that they would thoroughly prove the commercial practicability of and demand for cyanamid before building a large plant. After two years' experience they realized that the product could be looked upon as an undoubted commercial success. Methods of manufacture have been simplified and cheapened, and it is now necessary to double the existing plant in order to cope with the increasing orders.

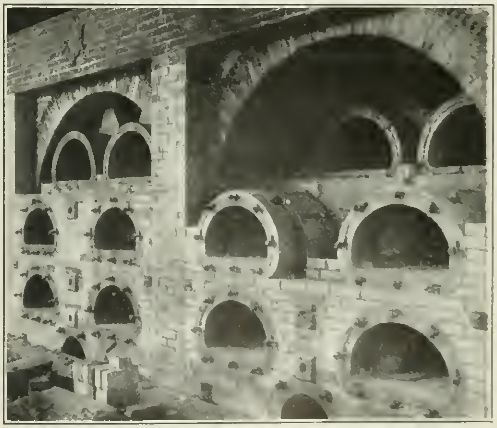


FIG. 3—MANNER OF LAYING UP THE SECTIONAL SILICA RETORTS AND SETTINGS

Cyanamid is a bluish-black, odorless, powdered material. It contains from 18 to 20 per cent ammonia, about 12 per cent carbon, or lamp-black, and the equivalent of about 70 pounds of slaked lime. The material is shipped in burlap bags and can be stored indefinitely.

Cyanamid nitrogen is readily soluble. Ninety-six per cent will dissolve out in cold water and is, therefore, available as plant food. On contact with the soil it reacts quickly and changes finally into the form of double ammonium compounds.

Every 100 pounds of cyanamid contains the equivalent of about 70 pounds of slaked lime which adds considerably to its value as a fertilizer. This lime costs the farmer nothing, as cyanamid is sold on the basis of the ammonia it contains as determined by analysis.

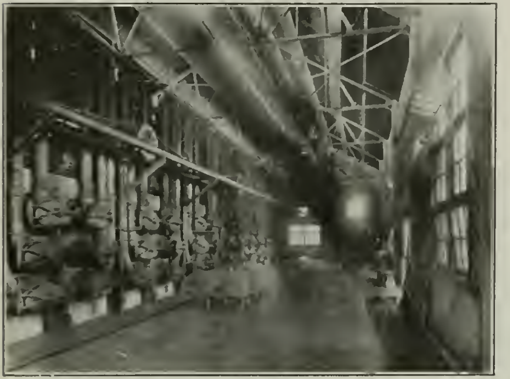


FIG. 4—CHARGING FLOOR OF RETORT HOUSE WITH CONVEYOR SYSTEM AND COAL BUGGY

### Starting Materials of Cyanamid Manufacture

Since calcium cyanamid is produced by the reaction of nitrogen gas with hot calcium carbide, and since calcium carbide is made in the electric furnace from lime and coke, the principal requirements of cyanamid manufacture are, besides cheap electric power, lime, coke, and nitrogen gas.

It should be emphasized that the nitrogen gas before being used must be separated from the oxygen gas with which it is mixed in atmospheric air. In some of the European cyanamid factories this is done by liquefying the atmospheric air and then separating the oxygen from the nitrogen by fractional distillation. At Niagara Falls another purely chemical and very simple method is employed. The atmospheric air is passed through a hot copper sponge whereby the oxygen in the air combines with the copper and leaves practically pure nitrogen. The copper oxide is then reduced again to copper sponges in a second stage by means of coal gas as reducing agent. The reduced copper sponge reacts again with atmaspheric air and produces nitrogen and so on. The copper sponge, therefore, undergoes cyclic oxidations and reductions.

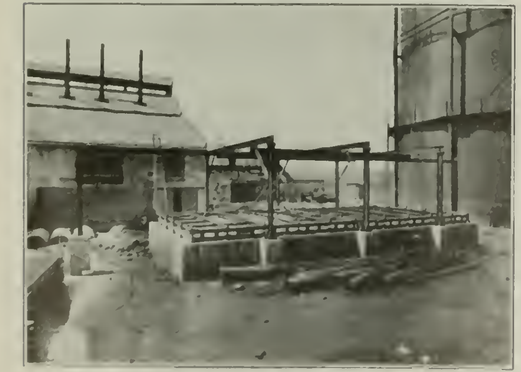


FIG. 5—PURIFYING BOXES

The nitrogen ovens consist of a series of vertical retorts heated by small individual furnaces. Copper sponge is placed in these retorts, and when the retorts are brought to the proper temperature air is forced through the retorts and the oxygen of the air combines with the copper as cupric oxide, leaving the nitrogen free. This is the first stage. In the second stage the air is then shut off and coal gas is passed through the retort, which reduces the copper oxide to metallic copper. The nitrogen produced in the first stage is forced through pipes into the electric furnaces where it combines with the calcium carbide and forms calcium cyanamid, or commercial cyanamid.

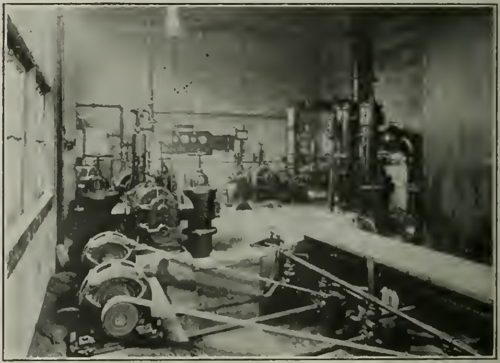


FIG. 6—MACHINERY ROOM WITH DOHERTY WASHER COOLER AND CENTRIFUGAL PUMP

### Coal Gas Plant

Since coal gas is used for the reduction of the copper oxide (in the production of the nitrogen gas) and since coke is used for the manufacture of the calcium carbide, a coal-gas plant is an important part of the factory, the coke going into the carbide factory and the coal gas into the cyanamid factory proper.

The coal-gas plant was designed and installed by the Improved Equipment Company of New York City, and has a capacity of approximately 500,000 cubic feet per twenty-four hours. There are seven benches of sizes equipped with the Doherty bench fuel economizer and sectional silica retorts and settings.

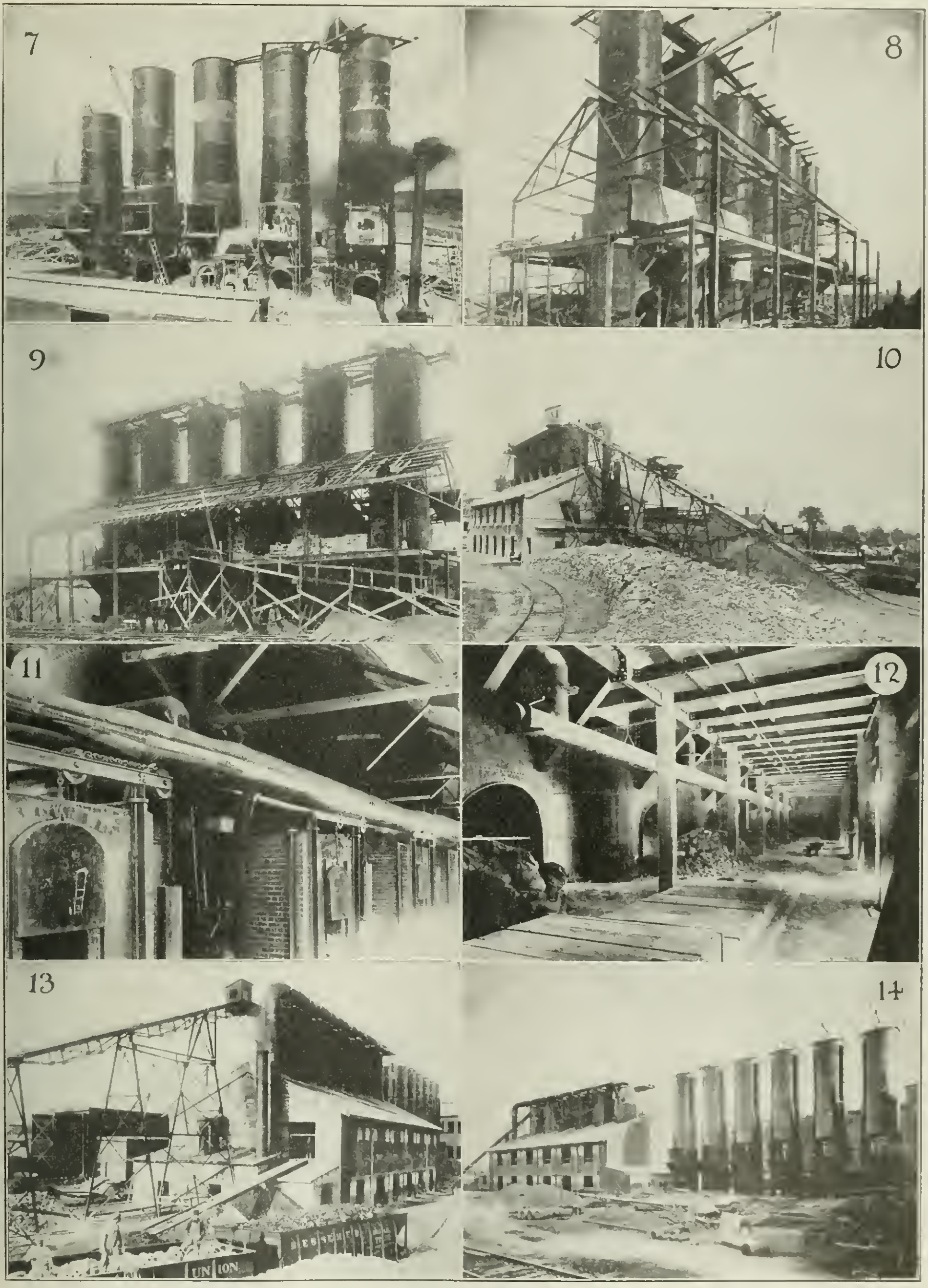
The accompanying illustrations give an idea of the principal features of this installation. The size of the whole plant can be seen in Fig. 1, with the lime plant at the extreme right and the coal gas plant at the extreme left.

Fig. 2 shows the retort house and holder and coal handling arrangements for the retort house.

Photographs were taken during the course of the installation of the plant, showing various stages in construction. Fig. 3, which shows the manner of laying up the sectional silica retorts and settings, should be of particular interest to gas men.

The view of the charging floor of the retort house (Fig. 4) shows the coke conveyor system and coal buggy.

The purifying boxes (Fig. 5) are of the concrete outdoor type. This view also shows the cooling coils of the Doherty washer cooler on the outside of the retort



FIGS. 7 TO 14—LIME PLANT IN COURSE OF CONSTRUCTION

Fig. 7—Kiln shells erected and fire-clay lining started; Fig. 8—kiln shells completed and section of waste gas piping installed; Fig. 9—work started on the roof of the lime-kiln building; Fig. 10—complete lime plant; Fig. 11—furnace or firing floor with piping for Eldred process and counterweight arrangement of the charging doors; Fig. 12—lime discharge floor. Fig. 13—old plant with new additions; Fig. 14—old plant with new additions.

house as well as the position of the holder which has a capacity of 100,000 cubic feet. This holder is only used as a relief holder when the nitrogen ovens do not use the output of the benches.

One of the interesting features of this installation has been the flexibility of the benches in that as a larger output is required the heats are raised and benches forced to meet the demand, or the heats are lowered when for some reason the nitrogen ovens are shut down or are not running to full capacity.

The view of the machinery room (Fig. 6) shows the Doherty washer cooler with centrifugal pumps for its operation.

### Lime Plant

For the manufacture of the calcium carbide which represents the first step in cyanamid manufacture, coke and lime are required. The coke comes from the coal-gas plant which is described.

The lime plant for the production of lime was also designed and installed by the Improved Equipment Company, and the original plant consisted of six Doherty-Eldred lime kilns equipped with the Eldred process and induced draft.

Figs. 7 to 9 show this plant in course of construction. In Fig. 7 the kiln shells are being erected and the fire clay lining started; in Fig. 8 the kiln shells are completed and section of waste gas piping installed, and in Fig. 9 work is started on the roof of the lime-kiln buildings.

The complete plant is shown in Fig. 10 with the incline for conveying the limestone to the top of the kiln.

Fig. 11 shows the furnace or firing floor, showing the piping for the Eldred process and the counterweight arrangement of the charging doors, and the view of the lime discharge floor in Fig. 12 shows the arrangement for handling lime and the holes for the conveyor in the floor.

At the present time the lime plant is being doubled in size. Figs. 13 and 14 show the new addition as well as the old plant.

---

**The New Heat Treating Department** of the Ingersoll-Rand Company's plant at Phillipsburg, N. J., which was installed by Tate-Jones & Co., Inc., of Pittsburgh, is now completed and in successful operation. The plant at Phillipsburg handles a large output of drills and compressors and the furnace equipment in this department consisted of two large double-chamber annealing furnaces, two semi-muffle furnaces for pre-heating, six lead and two solution baths for hardening and three oil baths for tempering. All of these furnaces are fired with fuel oil which this plant has been using with great success since changing from gasoline gas in January of last year. The complete installation of furnaces, burners and pumping systems was made by the Tate-Jones Company and they now have in the two heat-treating departments at Phillipsburg forty-three and in the blacksmith shop four Tate-Jones furnaces.

**Palace of Machinery at the Panama-Pacific Exposition.**—If confirmation is needed of the often-repeated press assertion that the San Francisco World's Exposition will open complete on time on February 20, 1915, it seems to be found in the present finished condition of the Palace of Machinery. It covers a floor space of about eight acres; water, gas, electricity, compressed air, steam, overhead crane service are all provided in systematic and comprehensive detail. The installation of heavy machinery should begin at an early date and shipments which reach the exposition by July 1, 1914, may be expected to be immediately put in place.

## New Metallurgical Laboratory in California

The new ore-testing laboratory of Mr. Charles Butters, at Oakland, Cal., is particularly designed for investigations in the treatment of refractory ores. Facilities have been provided for tests on any scale up to four or five tons, and suitable treatment can be determined for gold, silver or copper ores by any of the leaching processes in general use.

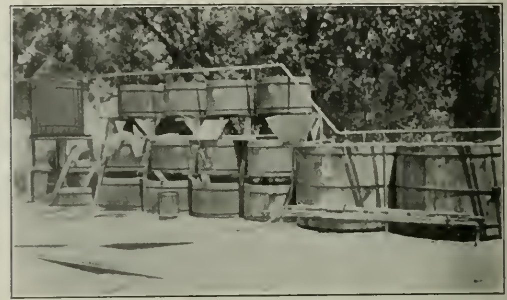


FIG. 1—LEACHING TANKS, BUTTERS' METALLURGICAL LABORATORY

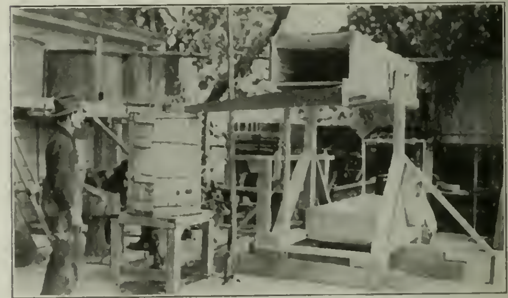


FIG. 2—VIEW OF BUTTERS' FILTER IN HORIZONTAL POSITION

The crushing appliances, which are all run by electric power, comprise two Grusonwerk ball mills, Gates gyratory crusher, Blake crusher, sample grinder and tube mills.

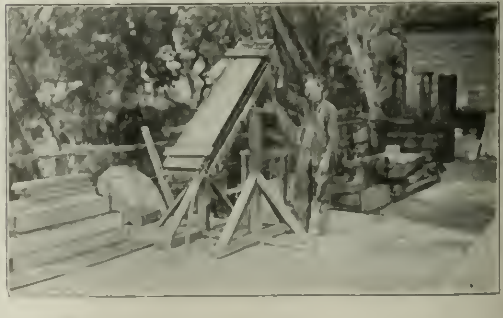


FIG. 3—FILTER IN INCLINED POSITION FOR DISCHARGING

Leaching and agitation tanks of various sizes have been erected. A general view of the leaching plant is given in Fig. 1. The agitation tanks comprise the regular mechanical type, Pachuca type and a form in which mechanical stirrers are combined with air-lifts.

The new type of Butters filter is shown in different views, Figs. 2 to 4. The details of this filter have been worked out at the testing laboratory. Fig. 2 shows the device in its horizontal position, ready to receive a charge of ore pulp. The apparatus consists of a number of superposed trays, each containing a filter mat of the regular type. These are charged simultaneously from a manifold that delivers pulp at one end of the apparatus. Fig. 3 shows the filter in an inclined position, ready to discharge. In Fig. 4 it is shown in the vertical position as it appears when the cake has been discharged.

Concentration tests can be made on the model Wilfley table shown in Fig. 4.

A zinc box of large capacity is provided for the recovery of valuable metals from cyanide solutions, and other systems of precipitation can be installed when necessary.

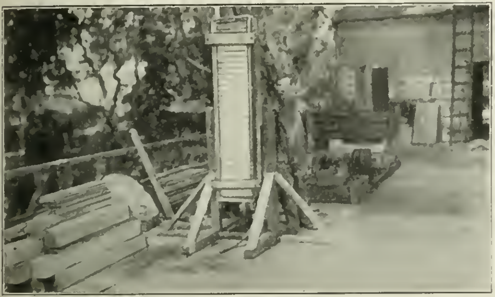


FIG. 4—FILTER IN VERTICAL POSITION, CAKE DISCHARGED

In addition to the experimental laboratory there is a well equipped assay office and analytical laboratory, the rooms used for this purpose being large and exceptionally well lighted, and furnished with every necessary appliance.

The entire installation is situated on the grounds of "Roselawn," Mr. Butters' Oakland residence. It is accessible both from Fifty-ninth Street and from Shafter Avenue, where the Oakland, Antioch and Eastern Railway affords a ready means of delivery. Rockridge station on this line immediately adjoins the plant.

---

**The Goldfield Consolidated Mines Co.** has declared a regular dividend of thirty cents per share, which will be payable on April 30 to stockholders of record on March 31.

**Butte & Duluth copper costs** for February are announced as $8\frac{1}{2}$ cents per pound. The company is treating oxidized copper ore by leaching and electrolytic precipitation. The ore averages 2.11 per cent copper. The cost per ton of ore was: Sulphuric acid, \$0.72; electric power, \$0.375; mining and transportation, \$0.23; fuel, \$0.14; labor, \$1.029; total, \$2.494.

**The Arizona Copper Co., Ltd.,** produced 1531 tons of copper during the month of February, 1914.

**A short course in coal mining** is announced by the Colorado School of Mines for the benefit of coal mine employees. The course lasts eight weeks, from April 1 to May 27. Elementary chemistry, geology, mathematics, mining, mechanics and drawing will be offered. There will be no fee for instruction. Small laboratory fees will be required. The course will aid candidates for positions under state civil service.

## Some Interesting Oil Tests

Even to-day, one frequently hears engineers speak of oil "wearing out," some even going so far as to maintain that after oil has been in use for a certain length of time it should be discarded and replaced by new oil.

In order to determine exactly what deterioration oil suffered when in constant use, the Richardson-Phenix Company recently had a rather elaborate series of tests made on different samples of oil at the laboratories of Cornell University.

These tests proved conclusively that if oil is properly filtered it can be used over and over again indefinitely without losing any of its lubricating qualities. To show the value of the information obtained in these investigations, the data secured from the Hotel McAlpin tests has been selected as representing the most severe operating conditions.

The power plant of the Hotel McAlpin, New York City, is equipped with a Richardson central oiling and filtering system, supplying flooded lubrication to four Wetherill engines having forty-eight points of lubrication, two Clayton air compressors having six points of lubrication, two Laidlaw-Dunn-Gordon compressors having sixteen points of lubrication and one Wetherill crank-and-flywheel pump having thirty-two points of lubrication, making a grand total of 134 points of lubrication supplied by the system.

This plant operates twenty-hours per day, 365 days per year, and the average temperature in the engine room is 100 deg. Fahr. On account of the great variety of machines lubricated, the high load factor and the exceptional temperature conditions, the work imposed on this lubricating system is probably as severe as can be found in any power plant. The oil is a good grade of mineral oil, known as "extra brand engine oil."

To find out exactly how much oil was circulated through the oiling system, ten tests were made at the power plant and it was found that the *average* amount of oil handled by the lubricating system was 150 gal. per hour, or 3600 gal. of oil per day. This is an equivalent of 1800 bbl. per month. It is interesting to note that although this enormous amount of oil is supplied continuously to the bearings, it is only necessary for this plant to add to the system 3 bbl. of oil per month, but even these 3 bbl. cannot be charged to natural shrinkage in the system, for large quantities of oil are drawn off from the filters and used in cans for hand-oiling of small pumps, valve gears and other bearings not connected to the oiling system. But even charging 3 bbl. against the system it is evident that this plant pays for less than two-tenths of 1 per cent of the oil used for lubrication.

To determine the changes undergone by the oil, a sample of the new oil as received in barrels from the manufacturers was secured and also a sample of the oil drawn off from the clean-oil compartment of the filter. These samples were sealed in the engine room and shipped to the testing department at Cornell University, where without any further purification or filtration, a series of tests were made under the supervision of Professors Carpenter and Sawdon. The results of these tests are given in the accompanying tables and curves. They prove that a modern oiling system is without doubt one of the best investments that can be made in any power plant.

A series of friction tests were made on a Thurston railroad lubricant tester, having a hardened steel journal and bronze bearings with a total area of 20 sq. in. In all tests the testing machine was run at a constant speed of about 360 r.p.m. and the load applied in increments of 1500 lb. total pressure of 75 lb. per square inch. The test at each load was continued until the friction and temperature of the bearings had become constant. The oil was fed upon the side of the bearing through a sight-feed oiler and the feed maintained as nearly constant as possible throughout all the tests. Readings were made at ten-minute intervals and a large amount of interesting data secured. The summary of these tests is shown in the following tables:

SAMPLE "A"—NEW OIL

| | | | | | |
|---|---|---|---|---|---|
| Press. on bearing, total lbs. | 1500 | 3000 | 4500 | 6000 | 7500 |
| Press. on bearing, lbs. sq. in. | 75 | 150 | 225 | 300 | 375 |
| Duration of test, mins... | 120 | 50 | 60 | 60 | 50 |
| Temperature of bearing, max. | 114.5 | 120.0 | 129.5 | 139.0 | 143.5 |
| Temperature of room, aver. | 68.2 | 70.7 | 71.5 | 72.5 | 73.0 |
| Diff. in temp. bearing and room | 46.3 | 49.3 | 58.0 | 66.5 | 70.5 |
| Rate of feed, drops per min. aver. | 34.8 | 38.4 | 33.6 | 37.0 | 38.2 |
| Speed, R.P.M. | 362 | 361 | 361 | 361 | 359 |
| Speed, ft. per min. | 355 | 354 | 354 | 354 | 352 |
| Minimum coeff. of friction | .01166 | .00666 | .00533 | .00458 | .00373 |

SAMPLE "B"—PURIFIED OIL FROM RICHARDSON FILTER

| | | | | | |
|---|---|---|---|---|---|
| Press. on bearing, total lbs. | 1500 | 3000 | 4500 | 6000 | 7500 |
| Press. on bearing, lbs per sq. in. | 75 | 150 | 225 | 300 | 375 |
| Duration of test, mins.... | 150 | 60 | 60 | 80 | 50 |
| Temperature of bearing, max. | 120.0 | 125.5 | 132.5 | 144.5 | 147.2 |
| Temperature of room, aver. | 74.0 | 74.8 | 75.3 | 77.0 | 77.5 |
| Diff. in temp. bearing and room | 46.0 | 50.7 | 57.2 | 67.5 | 69.7 |
| Rate of feed, drops per min. aver. | 38.9 | 40.3 | 37.4 | 40.5 | 41.4 |
| Speed, R.P.M. | 363 | 363 | 360 | 361 | 358 |
| Speed, ft. per min. | 356 | 356 | 353 | 354 | 351 |
| Minimum coeff. of friction | .01265 | .00717 | .00522 | .00458 | .00367 |

The coefficient of friction in the above table represents the lowest value found for each load, that is, as soon as a given load is applied, the coefficient is, of course, high at first, gradually falling off until it becomes practically constant. This latter figure is the one shown in the table and represents the value that would obtain in ordinary practice where engines operate continuously for more than an hour. The temperature readings given in the table are the highest temperature reached for each load, that is, as each new load is applied, the bearing gradually heats up until the temperature becomes practically constant.

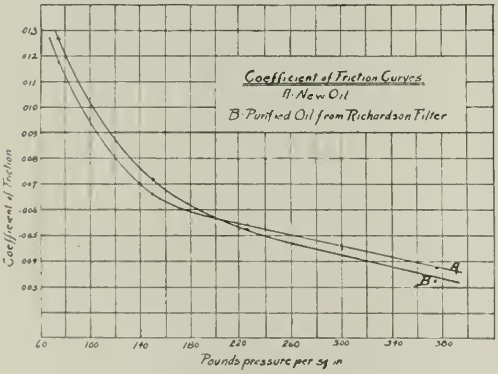


FIG. 1—COEFFICIENT OF FRICTION CURVES

The difference in temperature between the bearing and the room have been plotted in the curves shown in Fig. 2. Curves showing the coefficient of friction of the new and filtered oil are shown in Fig. 1.

As mentioned above, 3 bbl. of new oil are added to this system per month. However, the system as a whole has been in operation for over a year and a half and the question naturally arises, what physical changes, if any, has the oil undergone during this extended period?

The results of tests made to determine this are given in the following tables:

PHYSICAL PROPERTIES
Sample "A"—New Oil

Color: medium red, translucent
Flash point: 410° F. (open cup)
Burning point: 460° F. (open cup)
Specific gravity at 60° F. water as 1 = .895
Viscosity (with Olsen viscosimeter)
Water as 1 at 60° F. Time 27.9 sec. for 100 cc.

| Temperature F. | Time 100cc. secs. | Relative Viscosity |
|---|---|---|
| 70 | 97.0 | 3.48 |
| 70 | 96.6 | 3.46 |
| 71 | 96.2 | 3.45 |
| 97 | 59.8 | 2.14 |
| 94 | 61.8 | 2.21 |
| 130 | 45.6 | 1.63 |
| 132 | 43.8 | 1.57 |
| 214 | 34.0 | 1.22 |
| 215 | 34.2 | 1.225 |

Sample "B"—Purified Oil from Richardson Filter

Color: very dark red, opaque
Flash point: 410° F. (open cup)
Burning point: 440° F. (open cup)
Specific gravity at 60° F. water as 1 = .903
Viscosity (with Olsen viscosimeter)
Water as 1 at 60° F. time 27.9 secs. for 100 cc.

| Temperature F. | Time for 100 cc. secs. | Relative Viscosity |
|---|---|---|
| 68.0 | 138.0 | 4.94 |
| 69.0 | 134.0 | 4.80 |
| 70.0 | 130.2 | 4.66 |
| 103.0 | 60.4 | 2.16 |
| 114.0 | 50.6 | 1.81 |
| 130.0 | 45.2 | 1.62 |
| 152.0 | 39.0 | 1.40 |
| 147.5 | 40.2 | 1.44 |
| 218.0 | 33.2 | 1.19 |

The viscosity readings have been plotted in the form of a curve, shown in Fig. 3.

From the table it is evident that the oil has gained in specific gravity through constant use. This is what one would naturally expect inasmuch as the oil, in passing through the bearings has had some of its more volatile constituents driven off, also a small quantity of cylinder oil used for lubricating the piston rods and stuffing boxes naturally finds its way into the oiling system. The viscosity curves also confirm this hypothesis as the tests show that the used oil has a higher viscosity than the new, clearly demonstrating that as oil is used over and over again in an oiling system it actually gains in body, provided, of course, the filter thoroughly removes entrained water, and this is the vital point of the whole system.

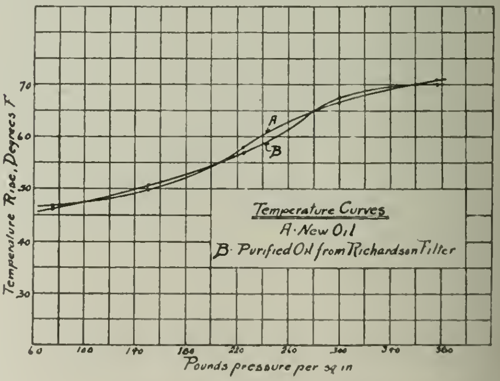


FIG. 2—TEMPERATURE CURVES

The results of the friction tests as shown in Fig. 1 are also consistent with these physical changes. It will be noted that the new oil has a slightly lower coefficient of friction on low bearing pressures, while the purified oil shows a lower coefficient on higher bearing pressures. This is due to the fact just noted. In other words, the old oil, having more body, is better able to maintain a lubricating film when subjected to higher pressures. Of course, the difference between these two curves is so slight that without any fear of contradiction one can say that for all practical purposes, properly filtered oil is as good a lubricant as new oil under all operating conditions.

The curves shown in Fig. 2 are probably the ones that will be most interesting to the operating engineer, as it is usually by the temperature of the bearings that he determines the quality of lubrication. As will be noted, these curves are practically superimposed and in no case is the variation more than a few degrees so that here again it is proven that filtered oil is as good as new oil.

Of course, it is needless to remark that in order to secure such remarkable results a highly efficient filter is necessary and the proposition of thus purifying oil on a commercial basis is naturally of considerable engineering interest. This plant is equipped with two new type Richardson power plant oil filters operating in parallel, each handling an average load of 75 gal. of oil per hour. In the design of these filters special attention has been given to providing a scientific method of precipitation.

Referring to Fig. 3, it will be seen that if the oil is heated to a temperature of about 150 deg. its viscosity is only slightly higher than that of water even after the oil has been in service a long time. Now, if oil at this temperature could be spread out in a very thin film, entrained water and other impurities which are heavier than oil would settle out very rapidly. Of course, it is impossible to spread the oil out very thin in a commercial filter handling large quantities of oil, as the size of the filter would be prohibitive. However, this principle has been utilized in the new Richardson filter. The dirty oil is first heated as it passes into the filter, after which it is carried to the bottom of a precipitation compartment where, by a novel arrangement, the oil is spread out to an area of about 14 sq. ft., but this compartment only occupies 2½ sq. ft. of floor space. The velocity of the oil in passing through this precipitation process is reduced to 0.2067 ft. per second. This extremely low velocity allows plenty of time for the precipitation process to be carried out in a highly efficient manner. The importance of thoroughly separating entrained water from the oil is demonstrated by the fact that at the Hotel McAlpin about 4 gal. of water per day is automatically separated and ejected from the precipitation chambers of the filters.

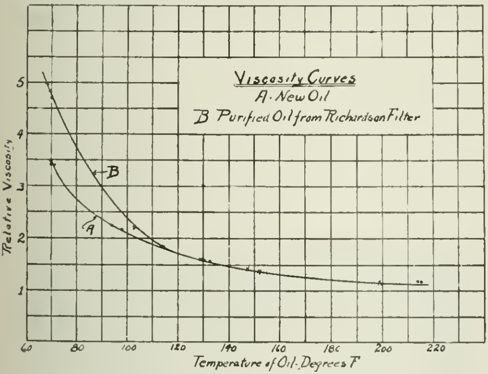


FIG. 3—VISCOSITY CURVES

The oil after being separated from entrained water and heavy particles of foreign matter in the precipitation chamber then passes directly to the filtering chambers, each of which contains twelve filtering units having a total filtering area of 3½ sq. ft. On this basis the filters are handling in a most efficient manner 2.4 gal. of oil per square foot of filtering surface per hour.

As the tests prove that the oil is purified in a remarkable manner, it is thus seen that with a properly designed system of precipitation a large amount of cloth filtering surface is entirely uncalled for. The disposition of the filtering medium is of far more importance than its quantity. It would be just as logical to buy engines by the pound as to purchase an oil filter by amount of filtering surface it is supposed to have and disregard its efficiency. The arrangement of the filtering medium in the Richardson filter is such that it is free from wrinkles and folds. Every square inch of surface is effective and an equal thickness of the filtering medium is interposed in the oil circuit at every point.

Tests have proved that when filtering cloth is adjusted in any manner that constrains it to arrange itself in folds or plaits, the portions of the filtering surface where the folds come interpose a greater thickness and the oil does not pass through these parts but is short-circuited through the single thickness portions, thus rendering large portions of the surface inactive. So efficient has its system of precipitation and filtering proven that the Richardson-Phenix Company has now successfully applied this principle to its entire line of filters, ranging from small hand filters having a capacity of a few quarts per hour to large filters capable of handling over 7500 gal. an hour.

The fact that a power plant like that in the Hotel McAlpin pays for less than two-tenths of 1 per cent of the amount of oil used and that oil can be purified in a commercial filter and returned to an oiling system in a state of purity equal to new oil, is certainly of vast importance in the economical operation of power plants, and the old-fashioned idea of purchasing a barrel of oil and letting it drip to waste is certainly as out of date and uneconomical as Watts' original scheme of condensing the steam directly in the engine cylinder. The saving in the cost of the oil in the above plant by the use of the oiling system amounts to over $2,000 per month, but who can compute the amount of coal saved by the reduction of friction or how much wear and tear on the machinery is reduced. It is safe to say that the money value of these savings is at least as great as the reduction in the oil bill.

The above data was furnished by the engineering department of the Richardson-Phenix Company, lubrication engineers and manufacturers, Milwaukee, Wis.

---

**Transvaal Gold Production.**—The number of companies reporting to the Transvaal Chamber of Mines in December, 1913, was 60. The quantity of ore milled during that period was 2,014,358 tons. There were 9722 stamps in operation, with an average duty of 8.63 tons per 24 hours. Tube mills in commission numbered 287. The yield for the month was 672,815 fine ounces gold. This report shows a marked decrease in tonnage treated and gold recovered as compared with the same month in 1912.

**The International Engineering Congress** is making rapid progress in working out the final program of papers to be presented at the sessions in San Francisco in 1915. The first volume of publications will consist of a series of articles descriptive of the technical features of the design and construction of the Panama canal. Each of the topics will be treated by some one of the canal force who has been responsible for the design and construction described. The program for the other sections of the congress is practically complete, and notices will be published in the near future. Membership in the Congress on March 1 was over 1200.

# A New Continuous and Dustless Dryer for Sludge Material

Drying is often a most trying proposition for chemical and metallurgical engineers, especially if the material to be dried is in a sludgy form and of such a chemical nature that the production of dust would seriously affect the welfare of the workmen.

What appears to be a very interesting and promising advance in the right direction is the recent development of the Macklind annular dryer by the Sherwin-Williams Company, of Cleveland, O., and its first installation at the Ozark Smelting and Mining Company's plant at Coffeyville, Kan.

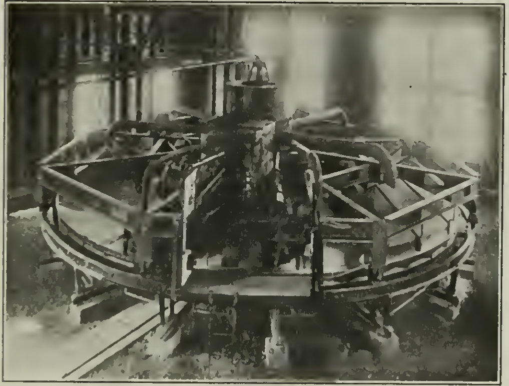


FIG. 1—MACKLIND ANNULAR DRYER AT OZARK SMELTING & MINING CO.

This machine was invented by Mr. W. R. Macklind, Managing Engineer of the Sherwin-Williams Co., and the specific purpose of the design was to produce a dryer that was continuous in operation, dustless and of high efficiency.

The principle of the Macklind dryer is to form a thin film, dry it and remove it in the shortest possible period in order that the material dried cannot be affected by the temperature. For this purpose the dryer is built in annular form and the period during which each film is being fed to the dryer, dried and removed is one revolution of the dryer.

The manner of operating at Coffeyville is as follows: The sludge material to be dried is pumped to the machine, varying from 60 per cent water and 40 per cent solids to 50 per cent water and 50 per cent solids. This sludge is delivered to the feeding cylinder over the feeding device, which device in turn deposits it on the annular surface of the machine. The spider of the machine revolves. The annular drying surface is stationary. The revolving medium makes a revolution every three to one and one-half minutes.

The machine being started, the feeding device thereupon commences to feed the sludge material in a thin film on the drying surface. In turn when the machine has made one revolution from the initial starting point, the removing device commences to operate, removing the dried material and carrying it to the center of the machine for final delivery to the packers.

From this time on the operation is continuous, feeding and removing, and the operator's only duty is to watch the machine and see that it is properly oiled and the proper speed of rotation is kept. This, however, becomes constant after the machine is set.

All vapor arising from the dried material is removed by means of the vapor hoods and connection pipes through the central vapor drum into the atmosphere. The circulation of this vapor-removing medium is carried on through induced draft.

All dust arising from the removing device is collected and deposited in a small bag collecting device in the center of the machine.

The Macklind dryer has been operating for some sixty days at Coffeyville on lead pigment and in addition extensive tests have been made in drying pulp white lead. These tests were carried on in the presence of experts from the National, Eagle White Lead and Hammar Brothers White Lead Works, and are stated to have proven conclusively the efficiency of the machine in drying white lead pulp from the standpoint of efficiency, continuity, rapidity and dustlessness. This latter feature is one of the most important phases of this new machine. The success of the machine in drying sludge white lead dustlessly—which is recognized to be one of the most difficult propositions—appears to open to the Macklind dryer a wide field of usefulness. For this reason the following details of its construction should be of general interest.

The dryer is circular and weighs 80,000 lbs. erected. It is 30 ft. in diameter and requires 14 ft. head room. The surface of the drying table is 40 ins. above the floor. The drying table, which is 6 ft. wide, consists of 40 semi-steel sectors and has a drying surface of 414 sq. ft. The sectors of the drying table are tested to 150 lbs. hydrostatic pressure.

The drying table operates with a pressure of steam from 50 to 90 lbs. The temperature of the drying table at 90 lbs. pressure is 330 deg. F., which is the maximum temperature at which the machine operates. The dryer is operated by three direct-current electric motors of 5 hp, 3 hp and ¾ hp respectively.

The material to be dried is forced by a rotary pump to brass reservoirs over feeding device. This reservoir serves the brass vibratory feeder which places the sludge on the drying table. The pressure of the material being fed is held constant by means of static head maintained by a rotrex pump. The dried material is removed by means of an enclosed removing device.

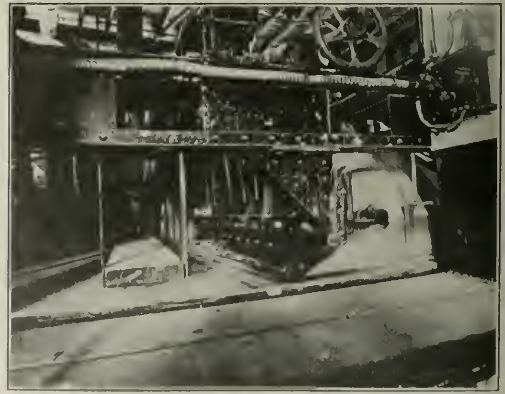


FIG. 2—FEEDING MECHANISM OF DRYER

As described before, the material is dried in one complete revolution. This takes from one to three minutes. White lead and leaded zinc pigments dry thoroughly with no perceptible moisture in one to one and one-half minutes.

The operator can control the rotating speed of the machines at will, so that one revolution may take from one minute to three minutes, or any intervening period.

While the machine will handle sludge materials containing 40 per cent water and 60 per cent solids or 50 per cent and 50 per cent respectively, it will not operate successfully if the sludge does not carry at least 40 per cent of water.

The dried material can be packed direct from machine without pulverizing, if desired, as it is in a granular state.

All vapors arising from the drying process are immediately removed and discharged into the air. The condensation from the drying table handled by trap can be used as pure water for manufacturing or returned to the boilers if desired.

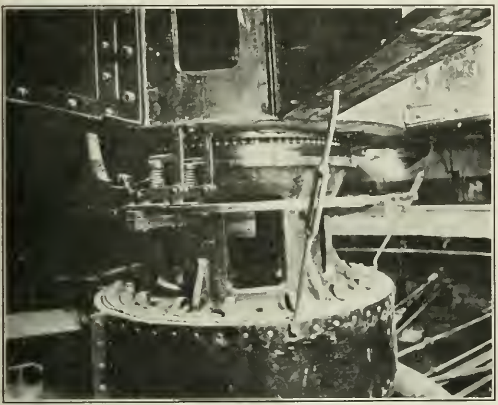


FIG. 3—CENTRAL COLUMN OF DRYER

The machine is operated by one man who has full control of all its movements which are handled from the operating platform which revolves with the machine. All movements are operated by electric motors.

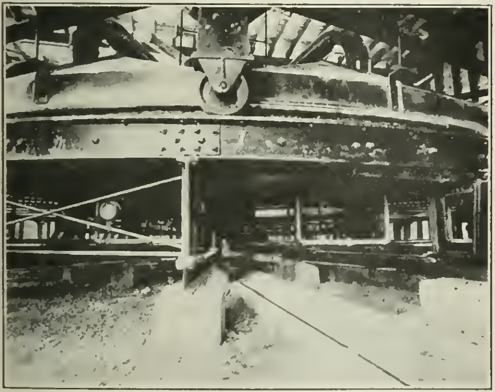


FIG. 5—DETAILS OF DRYER CONSTRUCTION

A dust collector takes care of the dust made in the removing device.

The use of steam in the machine insures an even temperature throughout the annular dryer table. The use of steam makes it possible to regulate the temperature according to the character of material being treated.

The efficiency of this dryer is stated to average about 75 per cent, though it naturally varies, depending on conditions. With dry steam and 50 to 45 per cent sludge a 75 per cent efficiency can be maintained. From the results obtained at Coffeyville it appears that the cost of drying sludge material as compared with dry-pan practice is cut in two.

In calculating the efficiency of the dryer, the formula $E = 100\ a\ b$ is used, where E is the efficiency of the machine, $a$ the heat utilized in evaporating water in the sludge to be dried and $b$ the total heat supplied to the annular table.

While the efficiency was stated before to average 75 per cent, the actual figures obtained with the machine in drying sludge consisting of 55 per cent water and 45 per cent solids were as follows: 2444 lbs. of water were to be evaporated for every 2000 lbs. of dried material. The number of B.t.u. required to evaporate the 2444 lbs. of water was 2,800,824, while the B.t.u. delivered to the annular dryer in the steam was 3,552,000. Therefore, according to the above formula, an efficiency of 78.8 per cent was obtained.

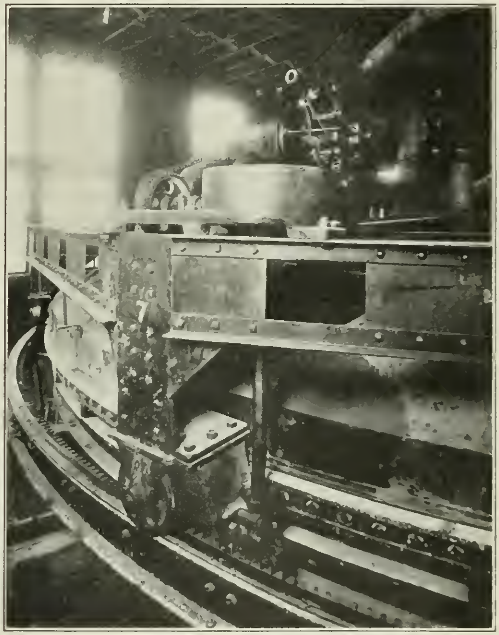


FIG. 4—DETAILS OF DRYER CONSTRUCTION

Fig. 1 shows the Macklind annular dryer as installed in Coffeyville, Kans. While its minimum capacity is 2000 lbs. of dry material per hour (the material going on machine from 55 per cent water and 45 per cent solids), the machine has a record of 3361 lbs. dried material per hour. This rate was maintained for a run of nine hours continuously.

Fig. 2 shows the bronze feeding mechanism of the dryer. This mechanism makes 300 vibrations per minute and sludge material is thereby fed in a perfect film onto the drying surface of the machine, shown directly underneath the feeding device.

Fig. 3 shows the central column of the dryer with the following details: Ball bearings of revolving frame spider, direct-current trolleys for supplying current for operating machine, revolving dust-tight drum connecting with jumper conveyor, which transmits dried material from table to center of machine for discharge.

In Fig. 4 are shown the main motor drive for rotating machine frame, radial rack of machine, details of castor at pinion drive, vapor hoods as suspended above drying table, ends of cast iron sectors showing core drawing plugs, vapor collecting drum in center of machine with main vapor discharge stack and induction air jet.

The details shown in Fig. 5 are steam connections, draining connections to sectors, super-structure frame, foundations, gauges for indicating pressure on sectors, vapor collecting hoods and supporting castor for revolving spider.

As the problem of drying materials in a sludge form comes up so often in chemical and metallurgical practice it will be interesting to watch the further career of the Macklind dryer after it has shown its usefulness for white lead. It is now being put on the market by the Sherwin-Williams Company, 601 Canal Road, Cleveland, Ohio.

## Duriron Castings for Chemical and Metallurgical Purposes

Among recent iron alloys, invented for special purposes, "duriron" is of particular interest to chemical and metallurgical engineers on account of its remarkable resistivity to chemical action.

Duriron is an iron alloy containing from 12 to 15 per cent silicon, while its other ingredients are being kept secret. It is suitable for most chemical apparatus or machines that can be cast and finished by grinding. Duriron is too hard to be machined.

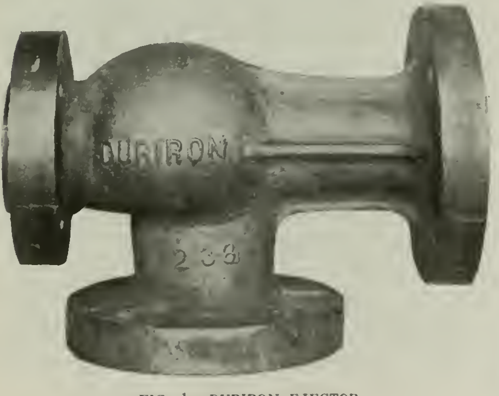


FIG. 1—DURIRON EJECTOR

The specific gravity of duriron is 7; that is, it is 4 to 7 per cent lighter than cast iron. The weight per cubic inch is 0.252 lb.

The tensile strength of duriron is 12,000 lb.; the compression strength 70,000 lb. The melting point is 2550 deg. Fahr. Its heat conductivity is higher than that of cast iron. It takes and retains a polish like nickel. In the design of duriron apparatus its shrinkage and high coefficient of expansion must always be considered. The shrinkage is 3/16 inch to the foot, the coefficient of expansion 0.00001565 per degree Fahr.

The most remarkable property of duriron is, as stated, its resistivity to corrosion. With few exceptions, duriron is not attacked by acids or alkalies of any strength. Of course, the resistivity of duriron to chemical attack depends somewhat on the temperature, decreasing slightly with higher temperatures.

The following results of immersion tests show the action of various acids on duriron.

Immersed in cold 25 per cent sulphuric acid, duriron showed no loss in one year, while cast iron was completely dissolved in sixteen days and wrought iron in thirty days.

Immersed in cold 25 per cent nitric acid, duriron showed a loss of 0.015 per cent in one year, while cast iron was completely dissolved in sixty-three hours and wrought iron in fifty-eight hours.

From results in actual practice it may further be stated that duriron is unaffected by acetic, tannic, hydrofluosilicic acid, copper sulphate, etc. It is resistant to phosphoric acid up to a certain strength, and is sometimes attacked by sulphurous acid. Duriron connecting-pipes of nitric and sulphuric acid stills have shown no apparent corrosion after one year of service.

The experience of a large aniline-color manufacturing plant is particularly suggestive. They have determined that in dyeing wool and cotton exactly the same shade and color may be obtained in duriron vessels as in porcelain. The slightest trace of dissolved iron would have a marked effect on the resultant color.

As to the resistivity of duriron to mechanical erosion as distinguished from chemical corrosion the report on the behavior of a duriron scraper in a salt cake furnace is interesting. In twenty-eight days of continuous operation at 900 deg. Fahr. the duriron scraper wore down ½ in., while cast-iron scrapers under the same conditions of operation wore down 3 inches. On account of this remarkable resistivity to erosion duriron is now being considered in connection with pneumatic ash-conveyor systems.

The adjoining illustrations show some interesting castings for chemical and general industrial work built by the Duriron Castings Company, 90 West Street, New York City, in their foundry in Dayton, Ohio.

Fig. 1 shows a steam syphon of duriron. One has been in use since last September with strong sulphate of alumina and so far not the slightest trace of corrosion or erosion has been found.

Fig. 2 shows a duriron centrifugal pump. In this case both the resistivity of the duriron to chemical attack by acids and its resistivity to erosion by grit and hard material are proving to be of greatest advantage. These pumps are of a very refined design and embody various features of particular value in pumps for handling acids.

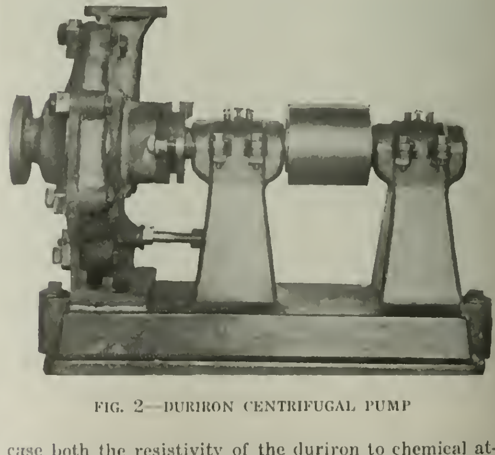


FIG. 2—DURIRON CENTRIFUGAL PUMP

Fig. 3 shows a partial installation of standard duriron pipe and a regular duriron cock, slightly modified to meet conditions. This standard pipe can be cut to length on order, and the use of compression couplings not only insures a stronger line, but each coupling constitutes an expansion joint. The Duriron Castings Co. also manufacture all kinds of special pipe. This pipe is used not only in chemical and metallurgical works, but is now also being widely employed in municipal water systems as they are not affected in the least by the sulphate of alumina solution employed in rapid filtration systems or by hypochlorite solutions now so generally employed as an after-treatment in water purification.

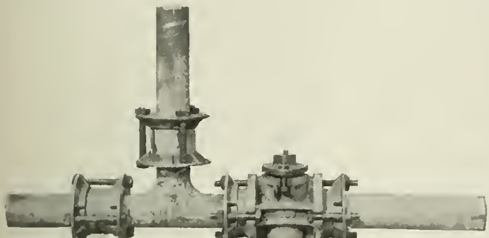


FIG. 3—DURIRON STANDARD PIPE INSTALLATION

Duriron cocks have recently undergone a careful redesign and reconstruction in which among other things special attention has been paid to correct taper which in general is hardly given the attention it deserves. As an illustration of their durability it may be stated that after months of continuous service, handling mixed acid (nitric as low as 18 per cent.) at 80 lbs. pressure, no corrosion or erosion could be detected. One of the great practical advantages of duriron cocks is that they do not stick even after long periods of idleness. Some users never grease them, some grease every four or five months, and others every four or five weeks. Their cost of maintenance is, therefore, very slight.

## A Small-Size Electric Arc Furnace for Melting and Refining

In 1912, Mr. Ivar Rennerfelt, a Swedish engineer, constructed at Hallstahammar, Sweden, an electric furnace, embodying some interesting novel features. The trial was so successful that, within a year, a steel foundry containing four Rennerfelt furnaces was erected at Hallstahammar.

Since then eleven other Rennerfelt furnaces have been erected or are in course of construction in various other plants in Sweden, Norway and Russia.

The principal field of the furnace is that of an economical small furnace for crucible works, steel foundries, copper and alloy foundries, etc. Its principle is applicable to small units of 100 kg as well as larger sizes, and the capacity can be multiplied almost at will by putting together a number of units as will be described later.

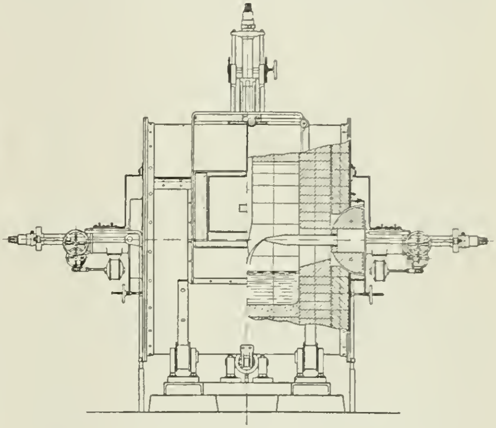
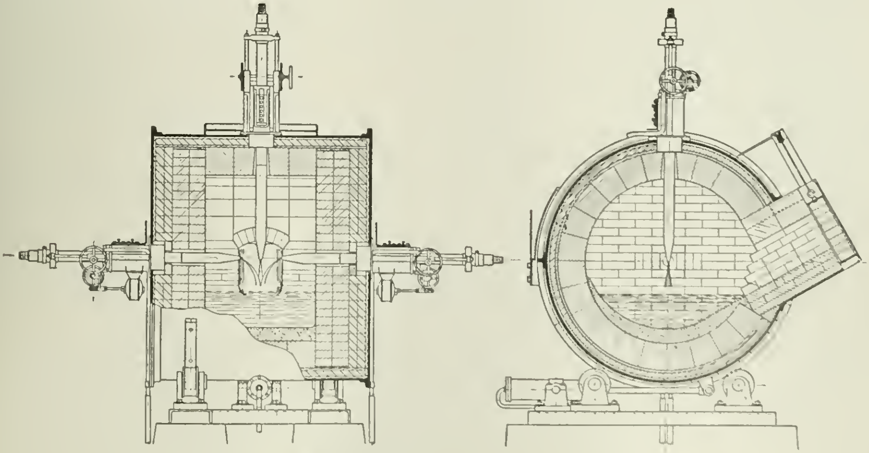


FIG. 3.—MODIFIED DESIGN

The Rennerfelt furnace is essentially a two-phase furnace. In case the plant is supplied with three-phase currents the well-known Scott transformation is employed to change the three-phase to two-phase currents.

There are three electrodes; one central electrode descending vertically through the crown of the roof, flanked on both sides by horizontal electrodes entering through the sides of the furnace. Fig. 1 shows the arrangement of electrodes with the side-electrodes sliding in fixed holders, but adjustable axially by hand or motor power. Fig. 2 represents a section of the same fur-



FIGS. 1 AND 2.—TWO VERTICAL SECTIONS OF RENNERFELT FURNACE

nace showing the charging and casting door placed in the circular wall.

Fig. 3 shows a sectional view of a furnace with the horizontal electrodes adjustable in the vertical plane. Electrodes adjustable vertically are preferably used when the furnace is employed for melting light scrap, requiring much space below the arcs, before it is melted.

The two side electrodes are connected to the two phases of the two-phase system respectively, while the vertical top electrode is connected to the neutral point. Fig. 4 shows clearly the electrical connections.

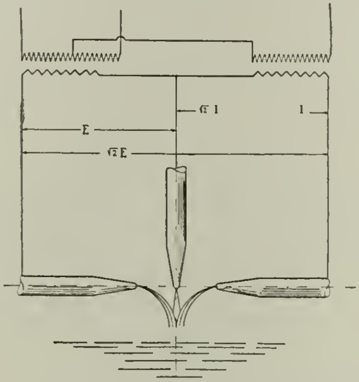


FIG. 4—ELECTRIC CONNECTIONS OF ELECTRODES

The principal novel feature of the Rennerfelt furnace is that as a result of the magnetic fields produced by the currents in the electrodes and in the arcs themselves, the arcs are deflected downwards onto the bath, thus forming the arcs into an inverted arrowhead or *fleud-de-lys*. The heat generated in the arcs is thus concentrated down upon the bath, though the electrodes do not touch or even approach the slag or metal. The arcs are sweeping or brushing all over the central space underneath the points of the electrodes, insuring a uniform heating of the charge and rendering the slag very fluid and chemically active. The height of the arcs from the points of the electrodes to the surface of the bath can be adjusted, but is usually kept at about 6 to 12 in.

In the riveted and strongly braced steel shell of the furnace is placed an insulating lining of asbestos board. Silica or first-quality firebricks in rings are built up against the asbestos board and form the bedding for the actual inner lining, acid or basic. This is made of special bricks requiring no cutting and set in rings of different diameters so as to form an egg-shaped interior melting chamber. The bull's eye around the charging door is carefully fitted into the lining. Special bricks form circular openings through which the electrodes enter into the furnace.

The life of the lining has not yet been finally established during the few months of actual operation, but a furnace with basic roof and hearth has run 102 heats without requiring any repairs outside of the ordinary fettling. A furnace with acid roof and lining operated continually day and night during two months and a half on acid tool steel, running not less than 174 heats. The temperature in the basic was kept considerably higher than in the acid furnace. The bottom of the hearth is practically undestroyable and may be used over again continuously when repairing the side walls and the roof.

The radiating heat from the free-burning arcs is reflected on to the bath from the entire mirror-like incandescent inner surface of the vault. Yet the arcs are at such a distance from this roof that the danger of melting the same is minimized. The shadow of the vertical electrode has a marked protecting influence on the vulnerable portion of the vault—the area around the entrance opening for the said electrode.

There is no sudden break between the roof, sidewalls and bottom, all being built together in one continuous curve. Owing to the circular form of the roof, the arch is very strong, and the disadvantage of expansion and contraction of the lining is greatly reduced.

As to the consumption of the electrodes the following information is given:

In a 600-kg. (1320-lb.) furnace running continually on charges of cold scrap and pig the average consumption of electrodes has been found to be about 2.8 kg. (6.2 lb.) per ton of steel. This figure represents the gross consumption, as there are no stumps left unconsumed.

Even when melting pig iron and afterward decarbonizing it by means of ore, the consumption of electrodes has not exceeded 3 kg. (6.6 lb.) per ton, in spite of the highly oxidized slag carried on the charge.

The wear of the side electrodes in a small furnace with acid lining using side electrodes of 2-inch diameter amounts to about 1 inch of electrode per hour.

Three such electrodes being used, wear of the electrodes in 24 hours will equal about 6 kg. (13.2 lb.). If the furnace is kept running at full power, 5 heats of 600 kg. (1320 lb.) or 3 tons of steel are produced in 24 hours, making the consumption of electrodes 2 kg. (4.4 lb.) per ton, if reasonable care is exercised.

The power factor is stated to be above 0.9. In one instance a value of 0.97 has been ascertained at a furnace operated with a current of 50 periods.

As to specific power consumption the following data are given:

According to records taken by registering kw-hour-meters a small furnace of 600 kg. (1320 lb.) at the Ljusne ironworks melted and refined a full charge of cold scrap with not more than 700 kw-hr. per ton. The normal rating of a furnace of this capacity is 125 kw, but according to records 80 to 90 kw are sufficient to complete a 600 kg. heat in 5 hours' time, indicating a very satisfactory thermal efficiency even when running with only 75 per cent. of full load. White pig iron has been melted in the same furnace under similar conditions with 405 kw-hr. per ton. This figure is an average of four consecutive records.

In one instance gray pig iron was melted and overheated with 425 kw-hr. per ton, including the melting of 22 kg. basic slag per ton of iron. Under very favorable conditions it has, however, been possible to melt gray pig iron with about 300 kw-hr. per ton in a 600-kg. furnace.

Repeated and successful trial runs have proven that the Rennerfelt furnace is also well suited for producing high-grade tool steel from pig and ore. As indicated by recording meters a ton of pig iron charged cold can be converted into steel in a fairly large furnace with a consumption of about 850 kw-hr. If the iron is charged liquid, 350 kw-hr. may be saved; 500 kw-hr. would, therefore, suffice to decompose the ore required and to deoxidize the steel resulting from 1 ton of liquid pig metal.

The furnace is being used for steel foundry work producing excellent castings, thin-walled and of intricate forms. The steel is tapped very hot and often requires to be held in the ladle for sometime until sufficiently cooled off to make good castings. Cracks due to shrinkage and blowholes seldom occur in steel foundries using this type of furnace. Nickel-steel castings, manganese steel and acid tool steel have all been successfully made in the furnace. Motor-cylinders and other high-class pieces in pig iron have also been cast with perfectly satisfactory results.

The Rennerfelt furnace has also been employed for copper and brass melting. A small furnace of about 60 kw was charged with 95 kg. copper after having been brought to full temperature. The charge was completely melted after 30 minutes with an expenditure of 30 kw-hr. or about 300 kw-hr. per ton. Another charge of 44.5 kg. copper and 30 kg. zinc was entirely melted after 20 minutes, the energy consumed being 20 kw-hr. or 268 kw-hr. per ton of brass. The metal was poured into ingot molds and afterward drawn into tubes of excellent quality. At another occasion, the furnace was used for melting about 350 kg. of copper scrap with satisfactory results, the charge melting in a few minutes. The copper was perfectly dead and was cast into small blocks.

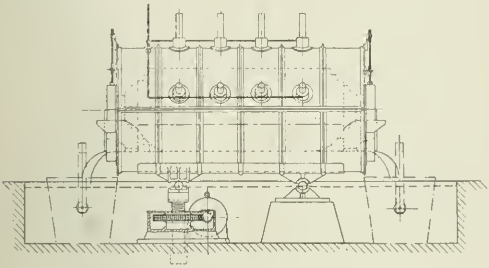


FIG. 5—MULTIPLE-UNIT FURNACE

The energy consumed per ton will, of course, be materially reduced, when dealing with larger charges in furnaces especially designed for special metals. The figures already obtained indicate, however, that the furnace will successfully compete with the crucible in brass foundries, especially as there is practically no loss from oxidation and as the metal is materially improved.

In order to make this furnace adaptable to large sizes, the "multiple-unit arc furnace" design is employed as shown in Fig. 5, which illustrates a furnace made up of four unit sizes side by side. The furnace is built as an elongated crucible of preferably cylindrically cross-section, made up of a number of similar sections bolted to one another and each fitted with one set of electrodes.

The patent rights of the Rennerfelt furnace are owned by the Aktiebolaget Elektriska, Ugnar, Fredsgatan 2, Stockholm, Sweden.

## Personal

Mr. **G. D. Van Arsdale**, chemist for the Phelps-Dodge interests at Douglas, Ariz. stopped in Denver last month to visit the plant of the National Radium Institute, of which Dr. James Douglas is one of the organizers. Mr. Van Arsdale will return to Arizona in about a month, after a trip through the East.

Mr. **Charles F. Burgess**, who for a number of years has been in charge of the Chemical Engineering and Applied Electrochemical Departments of the University of Wisconsin, has resigned his professorship to devote himself to the management of the Northern Chemical Engineering Laboratories with offices at Madison, Wisconsin. These laboratories are carrying on experimental and development work in chemical, electrochemical, and metallurgical engineering. Included in its technical staff are Carl Hambuechen, E. E.; Otto E. Ruhoff, B. S.; Walter B. Schulte, Ch. E.; L. T. Richardson, Ch. E.; O. W. Storey, Ch. E., and Arden R. Johnson, Ph. D.

Mr. **Charles Butters** has returned to this country from a visit to Salvador where he inspected the Butters properties.

Mr. **Franklin Guiterman**, of the New York office of the American Smelting & Refining Co., has been making a trip of inspection among the Colorado smelting plants owned by the company.

Mr. **J. M. Hyde** has returned to this country after a trip through Europe investigating new metallurgical processes. He will be American representative for the Murex Magnetic Co., Ltd., with headquarters at San Francisco.

Mr. **E. M. Johnson** has resigned his position as manager for the National Zinc Co.

Mr. **W. D. Leonard**, superintendent of the Garfield smelter of the American Smelter Securities Co., made a brief visit in Denver last month.

Mr. **L. M. Marshall** has severed his connection with the Cambria Steel Company to become chief engineer and assistant general manager of Messrs. A. J. Haws & Sons, Ltd., refractory manufacturers of Johnstown, Pa.

Dr. **Charles L. Parsons**, chief of the division of mineral technology, U. S. Bureau of Mines, has been in Denver to inspect the newly completed plant of the National Radium Institute, which is to be operated under an agreement between the Bureau and the Institute.

Mr. **August Raht**, who was closely identified with the early development of smelting in Colorado, was in Denver last month on a visit from his home in Santa Cruz, Cal.

Mr. **W. H. Staver**, formerly superintendent for the Liberty Bell company in Colorado, is engaged in cyanide experiments at Sonora, Tuolumne county, Cal.

Mr. **F. D. Weeks**, of the American Metal Co., spent a part of March in Colorado, visiting the Denver offices and Salida smelting plant.

## Digest of Electrochemical U. S. Patents.

PRIOR TO 1903.

*Arranged according to subject-matter and in chronological order.*

*Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.*

### ELECTROPLATING

3015, March 21, 1843, Daniel Davis, Jr., of Boston, Mass.

Relates to electroplating, particularly to electrogilding, and produces a "dead-gilding" effect by first electroplating with copper, then a layer of gold, or of the metal required. The layer of copper produces a deadening of the final layer in a thorough and beautiful manner. With iron objects, cyanide of potassium is added to the copper sulphate solution sufficient to produce a solution of the copper in the cyanide of potassium. The iron is then coated with copper from this solution, after which a thicker coating may be applied from the sulphate solution. The gold is then deposited.

17,095, April 21, 1857, Alonzo G. Hull, of New York, N. Y.

Relates to electrolytic apparatus for medical use, and consists of two cells communicating through a submerged, porous diaphragm through which also is a valved opening. When the valve is opened, a graduated amount of circulation of the liquid takes place; when closed, the porous diaphragm allows electric action to take place.

26,978, January 31, 1860, Matthew Edwards, of Cambridge, Mass.

Relates to oxidizing metals for ornamental purposes, and consists in connecting the metal to be oxidized as an anode in a suitable electrolyte. With copper or brass, and an electrolyte of sodium chloride, a black coating is deposited, while with an electrolyte of potassium chlorate the metal will be colored red. If the surface contains silver or other white metal, weaker electrolytes are used.

27,046, February 7, 1860, William B. Gillett, of Auburn, N. Y.

Relates to sharpening files by electrolysis. The file is connected as an anode in an electrolyte of dilute sulphuric acid, or of a suitable salt, the cathode constituting a metallic plate, or the metallic lining of the tank. The file may also constitute the electropositive element of a voltaic cell.

82,525, September 29, 1868, Maurice Herrmann Jacobi and Eugene Klein, of St. Petersburg, Russia, assignors to Green, Clay & Company.

Relates to the electrodeposition of iron on molds for engraving, stereotypes, etc. The electrolyte consists of sulphate of iron combined with the sulphates of either ammonia, potash, or soda; or the chlorides of these metals may be used with the sulphate of iron. The bath should be kept as neutral as possible, but a small quantity of weak organic acid may be present to prevent precipitation of basic compounds of iron. A small quantity of gelatine improves the texture of the iron deposit. In order to increase the rate of solution of the iron anode, thereby maintaining the strength of the electrolyte, the anode may be short-circuited with a piece of gas carbon, or other electronegative element, the carbon being placed in the same electrolyte, or in a separate porous cell.

89,523, April 27, 1869, Hiram Tucker, of Newton, Mass.

Relates to ornamenting metal articles by electroplating, and consists in first enameling or varnishing the article, then grinding or otherwise removing portions of the coating, and electrodepositing the desired metal on the exposed parts.

90,894, June 1, 1869, Hiram Tucker, of Newton, Mass.

Relates to ornamenting metal articles by electroplating; it resembles the process described in patent No. 89,523, except that a final "show coating" of gold, etc., is deposited on the exposed metal.

97,390, November 30, 1869, Kingston Goddard, of Richmond, N. Y.

Relates to electroplating articles such as pitchers, etc., made of wood or other non-conducting material. The wood or other material is coated with plumbago, or other suitable conducting material, and electroplated with one or more coats of suitable metal.

97,657, December 7, 1869, Reuben Lighthall, of Brooklyn, N. Y.

(Reissued as No. 4048, June 28, 1870.)

Relates to preventing or retarding the oxidation of iron when in contact with water, especially salt water, and consists in the application to the iron of such electropositive metals as zinc, or alloys of zinc and tin, etc., or the two metals separately. The electropositive metal may be fastened under a bolt, or otherwise, to surface condensers, pipes, ships, etc.

100,038, February 22, 1870, James Spooner Howard, of Mansfield, assignor to himself; E. Adams, Jr., of Attleboro; T. E. Grover, of Mansfield, and N. Carpenter, of Attleboro, Mass.

Relates to electroplating antimony; the solution is made up of six fluid ounces of sulphate of ammonia, one-fourth fluid ounce of cyanide of potassium, eight fluid ounces of sulphate of antimony, and one gallon of (soft) water. The solution is finally filtered. The proportions given may be varied to a small extent.

100,580, March 8, 1870, Elbridge G. Wright, of Boston, Mass.

Relates to ornamenting metals, etc., by electroplating, and consists in coating the article with a suitable resist, removing portions of the resist where it is desired to deposit, and cutting below the surface of the metal so that the deposit will be below the rest of the surface, thereby protecting it from being worn off when exposed, or while being cleaned, etc.

106,823, August 30, 1870, James Spooner Howard, of Mansfield, assignor to himself; T. E. Grover, of same place; E. Adams, Jr., and N. Carpenter, of Attleboro, Mass.

Relates to producing a permanent dull finish upon gun-barrels, etc., and consists in first nickel-plating the object, then electroplating iron upon the nickel; the iron is then oxidized with a solution consisting of ½ oz. copperas, 2 oz. corrosive sublimate, 2 oz. blue vitriol, 3 oz. spirits of niter, ⅛ oz. nitric acid, 2 qt. water. Several applications of this solution are applied to the iron deposit, an hour or more elapsing between successive applications, depending upon the color of finish desired.

109,508, November 22, 1870, Cornelius Godfrey and Reuben Lighthall, of New York, N. Y.

Relates to preventing iron from rusting, and consists in electrodepositing an electropositive metal, as zinc, or alloy, such as alloys of zinc and tin, on the iron to be protected.

113,090, March 28, 1871, John J. Pratt, of New York, N. Y.

Relates to the manufacture of sign plates, etc., and consists in painting letters and numbers with a suitable resist on a metal surface, electroplating the unpainted portions with a desired metal, and then removing the resist, exposing the letters and numbers in the underlying metal below the electroplated surface.

129,207, July 16, 1872, Leopold Brandeis, of Brooklyn, N. Y.

Relates to bronzing columns, pillars, monuments, etc., of iron, and consists in cleaning them with a sand blast, then applying a coating of copper from a solution of a copper salt, or by electrodeposition, then electrodepositing a coating of zinc or lead. If a bronze-antique is desired, a second deposit of copper is made on the zinc or lead coat.

149,974, April 21, 1874, George W. Beardslee, of Brooklyn, N. Y.

Relates to electrodepositing cobalt, and describes preparing an electrolyte by dissolving metallic cobalt in hydrochloric acid, evaporating the solution to dryness, dissolving from 4 to 6 oz. of the salt in a gallon of distilled water, and adding ammonia until the solution is slightly alkaline. The anode consists of cobalt granules or fragments surrounding a carbon plate, and enclosed in a porous sack or envelope. During electrolysis, care should be exercised that the electrolyte remains alkaline.

172,862, February 1, 1876, Isaac Adams, Jr., of Boston, Mass.

Relates to the electroplating of cobalt. Refers to the prior art as found in literature, and points out the disadvantages of several processes. Describes methods of preparing the double chloride of cobalt and ammonium, and of cobalt and magnesium; also the double sulphate of cobalt and ammonium, and of cobalt and magnesium. These salts are dissolved in water to a strength of 6° to 7° Baumé, and maintained neutral. Metallic cobalt is used for the anode, made by reducing tartrate of cobalt with lampblack in a hessian crucible. When electrodepositing on zinc, first give the zinc a coating of copper.

# Metallurgical and Chemical Engineering

A Consolidation of ELECTROCHEMICAL AND METALLURGICAL INDUSTRY and IRON AND STEEL MAGAZINE

VOL. XII NEW YORK, MAY, 1914 No. 5

PUBLISHED MONTHLY BY THE
McGraw Publishing Company, Inc.
JAMES H. MCGRAW, President.
C. E. WHITTLESEY, Secretary and Treasurer.
239 West 39th Street, New York.
TELEPHONE CALL, 4700 BRYANT.
CABLE ADDRESS, METCHEM, NEW YORK.

WESTERN OFFICE.................421 Boston Bldg., Denver, Colo.
CHICAGO OFFICE.........................Old Colony Building
PHILADELPHIA OFFICE................Real Estate Trust Building
LONDON OFFICE............Hastings House, Norfolk St., Strand

E. F. ROEBER, PH.D., Editor.
H. C. PARMELEE, Western Editor.

J. M. MUIR, Manager.

*Yearly subscription price for United States, Mexico and United States dependencies,* $2.00; *for all other countries,* $2.50. (*European exchange,* 10 *shillings,* 10 *marks,* 12.50 *francs.*)

Copyright, 1914, by the McGraw Publishing Company, Inc.

Entered as Second-Class Matter at the Post Office at New York, N. Y., under the Act of Congress, March 3, 1879.

NEW YORK, MAY, 1914

CONTENTS.

EDITORIAL:

Industrial Peace .......... 279
Copper Hydrometallurgy at Chuquicamata .......... 279
Federal Mining and Metallurgical Legislation .......... 280
A Change in Engineering Education .......... 281
The Wage Problem in the Steel Industry .......... 281
The Tango of the Electrochemists at the Chemists' Club .......... 283

READERS' VIEWS AND COMMENTS:

A New Design of Filter Press. By W. Motherwell .......... 284
Value of Research Work. By C. J. Barton .......... 284
The Technical Parasite. By X. Y. Z. .......... 284
Central Research Organizations. By Parker C. Choate .......... 285
A New Source of Zinc Ore. By H. A. Mereness .......... 286
Blast-Furnace Blowers. By C. E. McQuigg .......... 286
The Western Metallurgical Field .......... 286
The Iron and Steel Market .......... 288
The Possibilities of St. Louis as a Field for Electro-Chemistry. By C. F. Carrier, Jr. .......... 289
The Development of Copper Leaching and Electrolytic Precipitation at Chuquicamata, Chile. By E. A. Cappelen Smith .......... 291
The Cost and Advantages of Using Electrically Melted Ferromanganese .......... 295
Salt Lake City Meeting of American Institute of Mining Engineers .......... 296
Is there a Complex Ore Problem? A Symposium .......... 297
The Metallurgical Engineer in the Steel Works. By John Howe Hall .......... 303
Cascade Attachment for Graphite Furnace. By E. F. Northrup .......... 305
The Igneous Concentration of Metallic Values from Mixed Sulphides—II. By F. L. Clerc .......... 307
Rapid Method for the Determination of Chromium in Pig Iron, Cast Iron and Steel. By H. E. Waters .......... 310
Blast-Furnace Blowing Apparatus. By J. E. Johnson, Jr. .......... 311
Notes on Chemistry and Metallurgy in Great Britain .......... 325
New York Convention of American Electrochemical Society, with abstracts of papers by C. P. Steinmetz, P. W. Sothman, F. A. J. FitzGerald, W. S. Horry, J. A. Holmes, W. D. Bancroft, C. A. Hansen, E. B. Clark, W. P. Lass, E. A. C. Smith, R. Gahl, R. W. Deacon, J. W. Richards, O. P. Watts and A. C. Shape, F. C. Mathers and H. M. Marble, C. W. Bennett, H. C. Keeney and R. P. Dougliss, C. W. Bennett and A. W. Davison, G. E. F. Lundell, E. F. Northrup, F. A. J. FitzGerald, C. N. Hitchcock, R. Beutner, E. L. Marshall, R. S. Owens, O. W. Storey, O. P. Watts and N. H. Li .......... 327
Some Economic and Aesthetic Aspects of Electrochemistry. By E. F. Roeber .......... 344
Celebration of School of Mines, Columbia University .......... 347
Personal .......... 347
Synopsis of Chemical and Metallurgical Literature .......... 348
Recent Chemical and Metallurgical Patents .......... 351
Mastic Lining for Acid Tanks .......... 353
Removal of Arsenic from Sulphuric Acid .......... 353
Improvement in Forging Practice .......... 354
Silico-Manganese .......... 355
Combination Portable Testing Set Using Resistance Thermometers and Pyrometers .......... 356
Uses of Asbestos and Its Products in Chemical and Metallurgical Industries .......... 356
New Electric Tachometer .......... 357
A Novel Branch of Research .......... 358
Hammer-Bar Pulverizer .......... 358
New Recording Pyrometer .......... 359
Notes .......... 360

## Industrial Peace

This country has suddenly become involved in a double war. Besides the war with Mexico we have the civil war in the Southern Colorado coal fields. While this journal is neither a mining paper nor a coal paper, the Colorado civil war is of such broad significance for our whole industrial life as to require comment.

We do not dispute in the least the wisdom of the operators to refuse to arbitrate the right of non-union men to work. But we seriously doubt their wisdom of refusing in the beginning any mediation whatsoever when besides the fundamental union principle, some five other points concerning the eight-hour working day, wages, etc., were at issue. It seems to us that then and there the operators lost a splendid opportunity to secure by diplomacy the moral support of the public.

Men are changing and things can no longer be run as they were run twenty or ten years ago. The president of a large public service corporation who recoined a famous old phrase into "The public be pleased" read the signs of the times correctly. In this new age made by the peaceful work of the engineer, only such policies can and will succeed as make for satisfactory relations between employer and employee for satisfactory relations between investors, utilities, and the public—for industrial peace.

## Copper Hydrometallurgy at Chuquicamata

Interest in copper hydrometallurgy justly centers in the work of the Chile Exploration Company at Chuquicamata, Chile, and the interesting experimental work which has been carried on in this country for over a year under the direction of Mr. E. A. Cappelen Smith. In studying Mr. Smith's description of the Chuquicamata copper deposits and the metallurgical investigations thereon, which we present on another page in this issue, the reader will be struck with the element of scientific, as well as financial, adventure which surrounds the past and future of this project.

Truly, a tremendous task has been assigned to metallurgical engineering. Responsibility for the expenditure of millions is imposed on a comparatively small group of engineers, in whom, also, the investors place their hope of financial success.

It may be argued that all mining and metallurgical schemes are, or should be, similarly conceived and executed, but in this instance we find some unusual factors. Precedent cannot guide; ingenuity must point the way; reliance must be placed on comparatively small tests; foresight must meet unusual conditions in a foreign land that is far distant from centers of manufacture and supply. In short, every detail must be worked out and proved successful here before it can be applied there.

And yet the thought presents itself that there are some elements in a venture of this kind that cannot be ascertained with absolute certainty, but only within limitations. Thus, only 600 tons of Chuquicamata ore have been treated experimentally in this country. The ore developed at the mines amounts probably to oved 200,000,000 tons. How truly representative of the ore-body is the quantity tested? We may assume that it is as representative as engineering skill could make it; and yet it does not compare in quantity with the amount of ore treated experimentally by, say the large copper companies in this country, before they settled definitely on their scheme of treatment and erected large mills. Six hundred tons of ore is not a large test-lot. Inspiration has prepared to treat that much per day in an experimental mill for concentration and flotation—processes that are reasonably well known and successful elsewhere.

This illustrates fairly the exceptional features of the Chilean project; probably it was more expedient to bring a small parcel of ore to a test plant conveniently situated, than to erect an experimental unit at the mines.

Other features of metallurgical adventure in the Chuquicamata project are found in the problems that called for original solution. The removal of chlorine from the copper solution, the selection of suitable anode material, the acid-proofing of concrete vats, and the mechanical methods of handling large quantities of ore, all presented interesting subjects for research. Apparently they have been dealt with successfully, and in a comparatively short time.

Not the least point of interest in the whole matter is the evident change in the attitude toward copper hydrometallurgy as evidenced by the magnitude of the project and the spirit with which it has been undertaken. Mr. Smith has been confronted with a problem which, in point of magnitude and novelty, has never been undertaken before. He has the best wishes of the metallurgical fraternity for the ultimate success of the venture.

## Federal Mining and Metallurgical Legislation

Until the Mexican situation demanded practically its entire attention, Congress exhibited signs of activity in legislating for the mining industry. The Senate was considering a bill to codify and suggest amendments to the general mining laws, and the House was concerned with a measure providing for the establishment and maintenance of metallurgical experiment stations. It was hoped and expected by the sponsors for these bills that they might be passed at the present session of Congress. As the bills stand it is doubtful if their provisions are wholly wise. They are open to serious criticism.

Sentiment among engineers and operators is generally favorable to a revision of the mining law, and the leading mining and metallurgical societies have had excellent committees working on suggestions. The present mining law was based on the knowledge of the science and art of mining many years ago. Since that time our knowledge has increased many fold; mining geology has revealed many new facts; general mining experience has proved the deficiency of the old law.

For the purpose of revision the Senate proposes the appointment of a commission of three members; two of whom shall be lawyers experienced in the practice of mining law, and one a mining engineer of practical experience in mine operation. It seems to us that this proposal is typical of legislation conceived by men not fully in touch with the practical conditions in the industry; and we believe that we voice the sentiments of many engineers when we suggest that this commission is not large enough and that there should be a preponderance of mining engineers and geologists instead of lawyers. The latter will be indispensable in properly framing the changes which the former suggest as a result of their knowledge and experience in mining; but the burden of suggesting changes naturally falls on those conversant with actual conditions. Therefore, one engineer is not enough; there should be at least three. These, with two lawyers, might reasonably expect to report amendments that could be adopted with the least disturbance in the industry.

In regard to the bill for metallurgical experiment stations, the features can be briefly stated as follows: Ten "mining experiment stations" are to be established in the United States and Alaska, under the control of the Secretary of the Interior. Each station is to be in charge of an engineer and a metallurgical chemist who shall receive annual salaries not exceeding $4,000 and $3,000, respectively. Each station is to receive an annual appropriation of $25,000 to buy supplies and equipment, and to pay salaries. The Secretary of the Interior may accept contributions of land, buildings, supplies or money from states desiring to cooperate with the Government in the establishment of these stations. Each of the stations, under the direction of the Bureau of Mines, shall make investigations in the mining and treatment of ores, with a view to increasing efficiency in methods and preventing waste, and shall disseminate practical information on these subjects.

A serious objection to this bill is the division of funds. An annual appropriation of $250,000 for the Bureau of Mines is a matter very different from appropriations of $25,000 each for ten experiment stations. Under the provisions of the bill there will not be enough money available for any one station to enable it to carry on serious investigations of any consequence, and there must inevitably be a duplication of work. In other words, the total appropriation will be spread out so thin as to be of little value; it will be consumed largely in maintenance and salaries. Under these conditions it is doubtful if the Government could produce appropriate results.

Perhaps the framing of the provisions of this bill is dictated, to some extent, by political necessity. In order to secure support for the expenditure of such a large sum of money, the appropriation is scattered over a large area and divided among a number of states. This may be good politics, but we believe it is not in the best interests of the industry. If funds are to be provided for mining and metallurgical investigations, they ought to be concentrated instead of scattered.

## A Change in Engineering Education

Columbia University announces a change in the conditions for admission to its engineering schools. Candidates will be required to present evidence of preparation in general educational subjects equivalent to three years' study in the regular college course. Such a procedure has been done already at Harvard and is similar to German custom. This is what is required of the candidates for law and medicine and is a recognition of engineering as a profession of the same dignity as law and medicine and requiring much the same educational foundation. With the splendid facilities offered by Columbia this raising of the standard will give us an engineering school of as high a rank as any in the world. At Harvard the graduates receive the title of Doctor of Engineering.

The effect of this on the profession cannot be other than good. Of course, there will always appear occasionally a young man bound to acquire an education while engaged in practical work, as Abraham Lincoln made himself master of his profession without any educational advantages. If another John Fritz should be born he would be John Fritz still, even if he never earned an academic degree, just as Faraday was a great physicist and electrician by nature. It is possible that men of this type would not be helped by a technical education; indeed, some psychologists hold that they would be injured by making the initial steps too easy. But they are exceptional, probably we shall see only a few in a century, and educational institutions are intended for the general run of mankind. Again, there will always rise from the ranks men of executive ability, who pick up a scientific knowledge in the hard school of experience, and make invaluable superintendents or managers. Such men are entitled to be called engineers even if they cannot write two letters after their names. Such men, too, are not common, for executive ability is a gift of the highest value if combined with common sense and a kindly disposition.

Now the great body of men need training in theory as well as in the school of experience. Columbia will furnish a technical training of high grade, and it is wise to base this on some general culture, so that an engineer with a degree of Doctor of Engineering will have a working knowledge of at least one foreign language, an ability to write plain and forcible English, and a habit of taking broad views, created by some economic and historical study. On a cultural foundation it is intended to build professional training, and when to this professional training is added ten years of practical work her graduates ought to prove good all-round men and some of them engineers of a high grade. To repeat: there are some men bound to forge to the front in the engineering and in any other profession without much aid from educational training, but the great body of men must be trained early and started right. This, modern education proposes to do, merely insisting that the young men she teaches shall come to her with a knowledge in outside subjects equivalent to what they would acquire by three years of college. Then she will teach them more in a year than they could learn in five in the rough and tumble of practical work.

Many graduates of professional schools never follow up the profession; for instance, an opening in a patent lawyer's office may give one an opportunity and he takes it. Some graduates of the engineering schools will doubtless drift into other employments. A well-trained engineer can easily become a patent lawyer. Conversely a patent lawyer should know more than he usually does about engineering. The big cases turn on engineering questions. The engineer also sometimes makes a good business man. But the great benefit of an education not used for its earning capacity is that it gives an interest in life. To an engineer a mine, a smelter, a machine shop, an electrical plant, are objects of the highest interest, as much so as forest is to the trained forester. The more he knows, the keener his interest, and to take an intelligent interest is really to live, and to produce results.

There is a peculiar fitness in making Columbia the center of a great technical school. Its first president, Samuel Johnson, a great Hebrew scholar, was a friend and admirer of Benjamin Franklin, who had an influence on him and Columbia. He conceived the idea of having what was then called "natural philosophy" taught in the college which he was founding. The correspondence between the two shows the interest felt in electricity at "King's College" even at that early date. Neither of these men could have imagined that this germ should grow into the School of Mines and later into the three great affiliated schools of science which are now to be raised to a higher plane. The methods of teaching science have developed as rapidly as science itself, to which "the Arts" so long revered as the acme of education are now to furnish a preliminary training.

## The Wage Problem in the Steel Industry

The wage problem in the steel industry is peculiarly complicated. The problem has its practical, its economical, its technical, its sociological and even its legal aspect. To speak of the legal aspect of a wage problem may seem strange, when there are no contracts to speak of between manufacturers and men, yet there is undoubtedly a legal aspect to this problem. The United States Steel Corporation, which makes approximately one-half the steel in the country, is defending a suit brought in October, 1911, for its dissolution, so that it is practically fighting for its very life. In its defense it has cited its liberal, enlightened and progressive treatment of its employees as one of its *raisons d'être*. It can be cited as a fact that the management of the steel corporation is strongly opposed to wages being reduced. It would be unfair, and we believe entirely incorrect, to infer that the pendency of the dissolution suit has anything to do with its attitude; but it is perfectly fair to hold that were there no other considerations the management would be justified, as men commonly look at things, to avoid a wage reduction when its conduct is being scrutinized from the standpoint of the common welfare. In another respect the wage problem has a legal aspect, for when it developed recently that a number of independent steel manufacturers had conferred in Pittsburgh relative to the advisability of reducing wages, a resolution was promptly introduced in Congress that the subject be investigated.

Experts in steel market conditions and movements insist with one voice that a reduction in wages would not widen the margin between production cost and selling prices. The steel market is wide open and strongly competitive, presenting a contrast to conditions which prevailed frequently prior to 1911, and the opinion is strongly expressed that a saving through a wage reduction would immediately be given away to the buyers of steel, the only effect upon the volume of business being to delay buying until buyers became assured that the full measure of the saving in wages was written into market prices. Thus from the practical or commercial viewpoint the question of reducing wages may be dismissed without further discussion.

From the economic aspect the problem is a much more difficult one. Two things usually are granted, that the division between labor and capital in manufacturing should be equitable, and that wages should be arranged with reference to the cost of living. When applied to the steel industry, however, these principles have opposite applications. Selling prices of steel are extremely low. They are but slightly above their historic low point of the late nineties and the subsidiary low point reached somewhat more than two years ago. They are very far below their high points of 1899, 1902, 1906-07 and 1909-10. Indeed, in all the past the tonnage sold at prices lower than those now prevailing is an insignificant percentage of the total tonnage which has been produced. The present wage rates, however, which date from the general advance of February, 1912, are the highest ever paid. According to the principle of equitable division between labor and capital, wages should now be reduced. But according to the other principle, involving the cost of living, they should not be reduced, for the last advance was based upon an increase in the cost of living and there has not since been any measurable decrease in that cost. By reason of these divergent showings, the study from the economic aspect gives no clear suggestion.

The sociologic aspect gives much more promise, but is clearly much more difficult for analysis and judgment. The procession of workmen through the iron and steel mill gates has changed in nationality time after time, but at all times the great mass of the labor has been composed of the more recent immigrants. For decades the American-born workman has been in the minority at the coke works and blast furnaces and in the iron and steel mills. The most cursory study shows it inconceivable that under present working conditions a change can occur in the direction of the American-born constituting a larger proportion of the working force in the industry. As the foreign-born die and the industry grows in size immigration must expand or working conditions must be changed so that American-born labor is attracted. Clearly it is a matter of serious import whether the United States should welcome to its shores increasing numbers of men who are content to do work which our own native born refuse to do. Apart from this sociologic aspect it is very pertinent to inquire, from the practical standpoint, whether it will continue to be possible for the industry to attract the immigration. With each of the countries which has in the past supplied us with so much of our population the movement to the United States has been more or less temporary. In turn, as conditions in their respective native lands improved, the men have been influenced to stay at home. Nor does it follow that if one emigrates he must come to the United States. In recent years there has been an important movement to South America, and year by year the amount of work which South America should and can do increases.

Whether the problem be to ensure a continuance of the flow of immigration for the maintenance of the iron and steel industry, by making the employment attractive, and at the same time make better men of the immigrants, or whether the problem be to attract American-born labor, the problem is a technical one, in that it involves the character of the service to be performed by the workmen and the conditions in which the service is performed. For this reason we included the technical as one of the different aspects in which the question of wages in the steel industry should be viewed, and in many respects the aspect is the most logical and promising. In the past few years the steel manufacturers have fully recognized the importance of improving working conditions, and encouraging a better home life. Millions of dollars have been spent along these lines and the disposition to effect these improvements grows as it is exercised. Despite these rapid improvements, however, the labor market has not been surfeited, but one finds rather that in recent years the periods of labor scarcity are more pronounced and the periods of unemployment are less marked, than was the case in the past.

It has been recognized by the sociological workers that seven-day labor, and apart from that twelve-hour-a-day labor, are undesirable from their standpoint, but a fact which these workers do not always recognize is that the workmen have opinions of their own. Not very long ago the United States Steel Corporation abolished seven-day labor in its plants, and the statement was made by Chairman Gary at the annual meeting of the stockholders April 20th that upward of 4000 men left the corporation's employ by reason of the change. The number of men who had been working seven days a week was not stated, but it is well known that it represented only a very small proportion of the total number of men employed by the corporation, so that the number of men who left must have been a very considerable proportion of the total number affected. There remains the twelve-hour day, with respect to a very considerable proportion of the men employed in the steel industry. As is well understood, the men do not actually labor during more than about two-thirds of the twelve hours during which they are technically on duty. There does not seem to be any particular reason why the service they perform should be reduced, but there are reasons which would make it advantageous for the work to be concentrated into a shorter period, whereby more time at home would be allowed. This is a technical question in works management. It has been very seriously considered already and is admittedly a very difficult one. It is a problem which must in nearby years be solved, though it certainly cannot be solved over night; but it is so important that the question of current wage rates cannot be approached without full reference to it.

---

## The Tango of the Electrochemists at the Chemists' Club

"And David danced before the Lord with all his might,—girded in a linen ephod."

We have often remarked in these columns that the great law of harmonic motion holds in other lines than that of pure physics. For example, the ebb and flow of material prosperity from boom times to hard times seems to follow with almost mathematical precision the same course as a pendulum. Individuals, too, are elated then depressed. Philosophy of one age is materialistic, of the succeeding age spiritualistic. So Fourier's series may be found to pervade the great world of men, women and things.

While it takes something more than Fourier's theorem to analyze any social change exactly, yet it must be apparent that the world now looks lightly on forms of amusement that formerly were condemned as vulgar, and the Puritanic notions of what is right and proper are being replaced by views Hellenistic in character. In short, the Greek pagan pantheistic idealism is being superimposed on our social structure. There are many evidences of this replacement. The prevalence of amateur and professional sport in daily interest, the freedom of dress that women are assuming, and finally the modern worship of Terpsichore that is increasing everywhere in the world are merely signs of the times. It was only a half a century ago that round dances were socially taboo and the advent of the waltz, polka and two-step was beset with vain remonstrances from society's mentors. This is remarkable but it is a fact.

The so-called modern dances growing so fast in popular delight are having a similar reception. They are, however, a perfectly natural concomitant of changes in other directions and have a clearly recognizable cause. This cause is natural physical relaxation that is needed after mental work. All intellectual or imaginative effort produces an effect on the sensory and motor centers of the brain. This is exerted harder and in more directions than heretofore because of intensity of modern thought. We can also adduce the theory that the thought centers of the brain are but glorified sensory or motor centers and that the former bear some relation to the latter as does the blossom of a plant to the leaf or as the cranium does to a vertebra. It was Goethe who pointed out first that the blossom was simply an extended and transcendental leaf and that the cranium was a development by functional evolution of the simple element of the backbone.

Accordingly, if we admit the theory that Goethe's discovery applies to the human brain, then on psychological grounds and also on physiological grounds, dancing of the tango or maxixe is due to the fact that the individual has had his thought centers greatly stimulated by many new things, and this calls for a balancing of his faculties by stimulation of the lower centers. Probably no better way for muscular exercise can be devised than dancing and probably in no way can the motor centers of the brain be better stimulated than by dancing. The great modern advances in thought, in art and in science produce marked effects on each and everybody's mind—mental displacements that, unless counterbalanced, can effect a permanent astatic mental condition. It is a rational procedure, therefore, to relax as in the present fashion in dancing, for the graceful movements of body to music produce a harmonic balance of motor centers and cause a normal return to equanimity. This is especially true if we admit the extension of Goethe's hypothesis of the glorification of an organ by its assuming a new function, for in that event the thought centers and motor centers are directly connected and no surer means of easing the former could be chosen than by easing the latter. Whether the modern dances are hurtful or vulgar depends entirely on how far the sex quality present in most forms of dancing predominates in both the conscious and unconscious mind, and that is entirely a question of individual self-restraint and good sense.

We can but admit, therefore, that the reaction from the Puritan notion that because a thing is pleasant, it is necessarily wrong, is a perfectly natural one and that the extension of human activity in a light and fantastic manner is normal and sound. The relation between dancing and religious activity as evidenced for example by the dancing dervishes or Shakers—"David danced before the Lord"—is a collateral line of thought. But what would the Calvinistic divines of the colonial period, such as Jonathan Edwards, have said to the tango or turkey-trot? Neither the sine curve nor signs of the times would have availed as an explanation to such worthies. The dance of the electrochemical scientists and engineers at the Chemists' Club would have been anathematized. But to them it was the charming finale of a glorious convention.

# Readers' Views and Comments

### A New Design of Filter Press

*To the Editor of Metallurgical & Chemical Engineering:*

Sir.—Having recently arrived from Australia, I have just seen the article in your February issue, entitled "A New Design of Filter Press," by Alfred Burger. If I understand the description aright, the same idea was put in practice at the Victoria Mill of the Waihi Gold Mining Company, New Zealand, when I was there in 1901. It was used to wash slime (200 tons per day) in Dehne and Martin filter presses after cyanidation, was invented by Mr. H. P. Barry, the superintendent, and was known as the "central wash." I believe it was also used at some of the mills at Kalgoorlie, Western Australia, about the same time.

W. Motherwell.

San Francisco, Cal.

### Value of Research Work

*To the Editor of Metallurgical & Chemical Engineering:*

Sir:—When the Wright brothers were experimenting with their gliders they were considered as "eccentric nuts" with a mania for flying. Nobody doubts now the fuuture commercial value or possibilities of the aeroplane.

Henry Ford was the target for ridicule in Detroit when he was "monkeying" with his first model. A few years later when cars were pretty reliable, although considered an expensive luxury, a very prominent business man was heard to remark that they might be a toy for the rich but they would never be used for trucking or other commercial purposes.

The above wellknown examples are typical of many other cases which have and will open fields of untold wealth to society. Many manufacturing institutions produce more wealth than gold mines for an equal amount of capital invested. This great earning power was made possible by the plodding research of some pioneer who single-handed had courage enough to venture out a little and match his starving along against his possible success. Then the miserly pittance that some of these same large firms give to further research work should shame their narrow grasping methods.

A prominent railroad after having been plundered time and again by financial pirates was in the receiver's hands. Then and not till then was an attempt made to improve the efficiency of the road. Now real road tests of the locomotives are being made by test cars placed between the locomotives and the train. The advice of the efficiency engineers will no doubt be followed and the earning power of the road will increase, the large as well as the small leaks will be stopped, and the road will get back on its feet again. Why should it be necessary for a railroad to get into a receiver's hands before steps are taken to increase the general efficiency and earning capacity of the road by employing efficiency engineers and experts to do research work?

A few of the larger concerns are spending many thousands to build and equip experimental laboratories to carry on experimental work along their particular line and find that it pays extremely well. Many others have contributed to The Mellon Institute of Industrial Research for scholarships. This manner of promoting investigation along new lines has proven very satisfactory to all concerned. For this method of providing means to carry on research work we are indebted to the foresight of the late Robert K. Duncan.

People are hunting to the farthest corners of the earth for radium bearing ore, especially since prominent authorities claim its value in the treatment of cancer. Thousands of dollars are being spent in this search and justly so. Money carefully spent in developing new industries or in improving old ones is likewise well spent and yields a wealth to society which cannot be estimated.

C. J. Barton.

Chicago, Ill.

### The Technical Parasite

*To the Editor of Metallurgical & Chemical Engineering:*

Sir:—Parasites are found in all walks of life and in all phases of human activity. They are as conspicuous in the technical world as elsewhere. The technical parasite is generally in the employ of a large manufacturing concern. He attends the meetings of scientific and technical societies, and even condescends to serve (?) on technical committees. While papers are being read or discussed he generally remains silent, seldom responding to an invitation to contribute to the discussion, more rarely still volunteering any information. His food consists chiefly of the crops laboriously raised by others and of this he partakes copiously and, if perchance he succeeds in raising a little himself, he guards it zealously for his own consumption. Notwithstanding this parasitic feeding, his attitude, instead of being one of humility and thankfulness, is often critical, not to say arrogant.

As a member of technical committees his work is seldom constructive. It is obvious that his interest in the labor of the committee ends when, in his judgment, it ceases to benefit him. He is secretive as to whatever information he has or fancies to have. While eager to receive, he is ever reluctant to give. He would even prevent the dissemination of knowledge likely to benefit others as it benefits him. He frequently affects to be the wise possessor of knowledge not available to the other members. This little game flatters his vanity.

What is there to be said in defense of the technical parasite? Certainly his vision is limited to the monetary value of his technical knowledge. He is unable to grasp the greater meaning, greater duty, and greater reward attached to a more lofty conception of the services owed by technical scientists to their fellow men. He apparently believes that he is serving the best interests of his employers—that his parasitic habits make him a more valuable man. In this egotistical attitude is he not misguided, even from a purely sordid point of view? To begin with, the exclusive knowledge he fancies or affects to possess is too often a mere *secret de polichinelle*. There are those who believe that a freer and more generous interchange of thoughts and information among technical men commercially engaged would promote progress in a way that must necessarily prove of much benefit to them. It is far from demonstrated that modern business, to be successfully conducted, is dependent on Chinese walls erected and guarded by technical parasites. It is now quite generally admitted that honesty is the best policy, in spite of the immediate returns which are seemingly within reach of the dishonestly inclined. Let us hope that the time will also come when the policy of free interchange of thought and knowledge will be recognized as the best policy by those sordidly inclined, in spite of the apparent gains to be derived from a parasitic policy.

Personally the technical parasite may be a very good fellow, but as a member of the great industrial, technical fraternity he is worse than useless. For my part, I should welcome the discovery and effective use of the exterminating bug that would put an end to his parasitic existence. X. Y. Z.

Cambridge, Mass.

### Central Research Organizations

*To the Editor of Metallurgical & Chemical Engineering:*

Sir:—The editorial re "Central Research Organizations" in your April issue prompts the comment that "research" being "invention," in its full development must utilize the strongest types of individuality, be controlled by personality and conducted by minds not essentially business.

The commercializing of the "research" idea as developed by personality may be possibly best conducted by a central organization, but the inventive ideas of great value can never be directed, controlled, or produced under organized effort. Invention is spontaneous like poetry, music and art.

Education helps, if not carried so far as to destroy originality.

Apparatus and finance are absolutely necessary especially in metallurgical work where volume is so necessary to prove or disprove a theory.

The same experiment may appeal to different minds very differently. The fact that one investigator sees only failure does not prove that another may not see success. It is best that the successful man does not know of all the failures of the unsuccessful or is not advised in the direction of his tests because of the failure of others.

Research can most efficiently be conducted under small units dictated solely by original personalities not connected in any way with commercial minds.

As results indicating industrial value are produced, the business mind or organization should take control, and it is to such organizations that research must look for all its finance, since its only product consists of merchandise that can be sold or utilized only by organized capital. To centralize research would be to suppress it in its highest development. However, the thought is unlikely of realization any more than the thought relative to the centralizing of poetry, music, or art.

PARKER C. CHOATE.

National Lead Co., Brooklyn, N. Y.

### A New Source of Zinc Ore

*To the Editor of Metallurgical & Chemical Engineering:*

Sir:—The recent discovery of a deposit of calamine at Embreeville, Tenn., furnishes us with additional proof of the elusive nature of the silicate and carbonate ores of zinc.

The new deposits are found on the property of the Embree Iron Company, Embreeville, Tenn., 11 miles from the main line of the Southern Railroad, being reached by a branch line from Johnson City. This property has been worked in the past for the rich deposits of hematite which it contains. A blast furnace with a capacity of 200 tons was erected in the late '80's, and was in operation intermittently until 1908 when it was blown out.

Throughout the whole period of its activity it was known that the ore being fed into the furnace contained amounts of lead and zinc, though no one seems to have suspected the presence of any great amount. At times they experienced considerable difficulty in making the furnace function properly, partly due to the excessive amounts of zinc and lead in the burden.

The hematite was mined by hydraulic methods which partly explains the reason why such a small amount of zinc-bearing ore found its way into the charge, for the calamine lies underneath the overburden of soil and hematite.

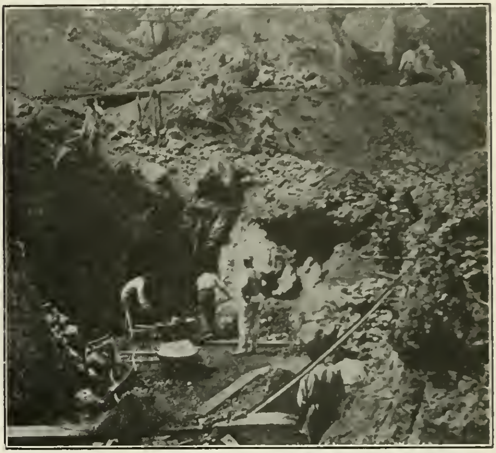


FIG. 1—OPEN CUT IN CALAMINE DEPOSIT, EMBREEVILLE, TENN.

Geologically the hematite and calamine lie in the Shady limestone, a Cambrian formation, along with the residual clays of the same formation, locally called "buck-fat." The calamine is found massive, that is, in lumps, in thin "stringers," and in granular form, all more or less mixed with the hematite-bearing soil, limestone, and "buck-fat." The associated minerals are hematite, galena, smithsonite and small amounts of cerussite and sphalerite, the latter mineral only in the limestone. The limestone is a dolomite, approximate $2CaCO_3.MgCO_3$.

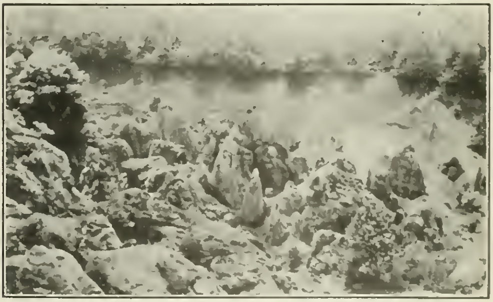


FIG. 2—ERODED PINNACLES OF SHADY LIMESTONE FORMED BY HYDRAULICKING FOR HEMATITE

The mining of the ore is carried on by means of open cuts and pits, the deeper deposits by tunnels and top-caving through "thunder-holes." The bottoms of the cuts have a gradient sufficient to allow tramming to be done by gravity.

The ore is hand-sorted in the cuts, the barren soil, limestone and clay being separated as far as possible from the zinc ore. The former products go to the "muck" pile, the latter to the washer to be treated. Temporarily the ore is being treated in a log-washer and a dry-house.

The mine cars run to a tipple on a trestle and dump on a grizzly with 3-in. spaces between bars, where it is washed with a spray from a nozzle. The oversize goes directly to the dry-house. The undersize discharges by chute into a 30-ft. double log-washer of the Longdale type. From the washer the washed material passes to a bucket elevator which discharges on a picking belt. The slimes pass to a slime pond.

On the picking belt the iron ore, limestone and country rock are picked, the zinc ore passing to a bin in the dry-house, from which it discharges to a tram-car and thence to the floor of the dryer.

The dryer is a structure 20 ft. by 120 ft., drying ore from 20 per cent to 5 per cent moisture at the rate of 30 tons per 24 hours. The finished product has the following approximate composition: Zinc, 33-38 per cent; iron, 11-15 per cent; moisture, 5-10 per cent.

H. A. Mereness.

Embreeville, Tenn.

## Blast Furnace Blowers

*To the Editor of Metallurgical & Chemical Engineering:*

Sir:—In a very interesting article by Mr. J. E. Johnson, Jr., in the April number of this paper nothing is said about the use of the centrifugal compressor on the iron blast furnace. Mr. Johnson's many years as a practical blast-furnace operator entitles his opinion to especial respect. It has occurred to the writer that a brief discussion of the results obtained from this comparatively new style of blower, when operating on the iron blast furnace might be of interest. It seems to be conceded that the following points of contrast between centrifugal and reciprocating blowers may be set forth.

(a) Mechanical Efficiency.—This is much higher with the reciprocating type than with the centrifugal —probably 90 per cent or more with the former—while with the latter probably not much in excess of 70 per cent.

(b) The Volumetric Efficiency.—This is usually quite high in the reciprocating type, due to skillful design as indicated by Mr. Johnson. As a general rule, the volumetric efficiency is higher than the mechanical efficiency in a reciprocating blower. However, it is apparent that any leakage due to worn or cracked valves, etc., will easily reduce the volumetric efficiency. On the other hand, it is claimed that the *initial* efficiency of the centrifugal blower, while relatively lower, is maintained indefinitely, owing to the fact that there are no rubbing parts except the rotor bearings. A slight clearance is left between the impeller tips and the guide vanes.

(c) The Item of Inertia is Important.—Mr. Johnson has shown some of the reasons for engines "pounding." This is not a feature of the reciprocating type, necessarily, but it is harder to eliminate than with the centrifugal type which may be nicely balanced. The writer has seen a single-stage centrifugal blower delivering 40,000 cu. ft. of air per minute at a discharge pressure of 4 lb. per square inch, with coins balanced on edge, on the casing.

(d) Head Room.—The economy of space required for housing is greatly in favor of the centrifugal compressor.

(e) The "Over-all" or Net Efficiency of the Blower and Its Driving Unit.—The practice of using reciprocating blowers with internal-combustion engines has been generally adopted. Its advantages are apparent. The subject is ably discussed in detail elsewhere by Mr. H. J. Freyn[1] and others.[2]

With the centrifugal compressor it is necessary to use high-speed drive, viz., a motor or steam turbine, either necessitating the generation of electric power in the gas-electric generator, or else steam in the boilers, using the blast-furnace gas. In either event, thermal losses occur.

It has been stated that the economy of the steam turbine-driven centrifugal unit is enough higher to warrant its replacing gas-driven reciprocating blowers.[3]

While this may hold in certain special cases, it would appear to be doubtful as a general statement under present conditions.

Automatic regulation of blast volume is a feature of the centrifugal type which is attractive. The crux of the matter is an economic one and appears to lie with the question of the driving unit. The perfecting of a gas turbine with high thermal efficiency may place the centrifugal blower abreast of the reciprocating blower for blast-furnace work.

C. E. McQuigg.

State College, Pa.

## The Western Metallurgical Field

### Brown Cyanide Process Decision*

In the issue of Metallurgical and Chemical Engineering for October, 1913, page 541, we commented on a decision of the United States District Court for the District of Delaware, in the case of Joseph A. Vincent vs. Tonopah Mining Co., et al. This suit was brought by Mr. Vincent as owner of patent 781,711, granted to Alden H. Brown Feb. 7, 1905, in which the patentee claimed invention of a process involving cyanidation followed by concentration. The Tonopah company was sued as infringing the patented process, and the District Court so held. Appeal was taken by the defendant to the United States Circuit Court of Appeals for the Third Circuit, which has reversed the original decree and remanded the case to the lower court with instructions to dismiss the bill for non-infringement.

Our comment at the time of the first decision was to the effect that we believed the patent could not be sustained in many cases, that it was of narrow application, and that its real import could not be gained until the case had been reviewed by a higher court. The Brown process was clearly defined as to certain successive steps in treating ores by cyanidation and concentration. * * * "First pulverizing the ore in the presence of cyanide solution; second, subjecting the ore to hydraulic classification by the introduction of cyanide solution at the bottom of an overflow tank to produce an ascending current; third, leaching the ore by the use of cyanide solution whereby the finer values of the ore are dissolved; fourth, removing the dissolved metallic values from the ore in any suitable manner; and finally, subjecting the residue of ore to concentration."

It appears that the process used by the Tonopah defendants involved crushing in cyanide solution, followed by concentration and subsequent cyanidation of the concentrates. Vincent sought to show that crushing in cyanide solution constituted essentially the cyanide treatment of ore by the defendant, and that the subsequent cyanidation of concentrates was an unimportant step, and that the process used was, therefore, essentially that of Brown. The Circuit Court of Appeals held differently, however: "After the defendant's concentration is finished the by-product goes forward to be subsequently treated by a protracted process of cyaniding. This is at variance with Brown's process in three respects; first, cyaniding follows concentrating (instead of preceding it); second, it is a system condemned by Brown and one he sought to avoid in that where 'concentration * * * is used preliminarily to the cyanide process it will be necessary to have a very extensive system of settling tanks in order to recover these suspended values and hold them in the mill so that they may be subjected to further treatment'; third, the defendant's process which physically withdraws from the operation of the process the products of concentration in advance of withdrawing those of cyaniding, makes the process one avoided by Brown, viz.: 'It is a well-known fact that the cyanide process recovers only the fine values, and in the treatment that I have devised these fine values are recovered by the cyanide process in the beginning, leaving only the coarser values, which are readily recoverable by concentrating, the latter being specially adapted for saving this class of values.' It is apparent, therefore, that the defendant's device, which the proofs show has been of great practical worth, owes its worth to the fact that it is built and operated in express disregard to the instructions of Brown's patent. Without passing on the question of the validity of that patent, it suffices to hold defendants do not infringe."

---

[1] "Operating Experiences with a Blast Furnace Gas Power Plant." Trans. Am. Soc. Mech. Engineers. "The Gas Engine in Modern Blast Furnace and Steel Plant." Ibid. Abstract of a paper read before the American Iron and Steel Institute—see *Iron Trade Review*, May 29, 1913.

[2] "Gas-driven Blowers at the Bethlehem Steel Co." Abstract of paper read before the Am. Iron and Steel Institute—see *Iron Trade Review*, June 19, 1913.

[3] L. C. Loewenstein, "Centrifugal Compressors," *General Electric Review*, March, 1912.

*See also the article on page 219 of our April issue.

Other extracts from the decision, showing the reasoning of the court, are interesting: "It will be noted that no new principle of operation, either in cyaniding or concentrating themselves was disclosed in this patent. It was at most simply a more effective treatment and it will thus be seen that transposition of concentration from initial to final stage, and of cyaniding from final to initial stage, is the substantial disclosure of this device. * * * This two-staged process—first cyaniding, next concentrating—being the only disclosure of Brown and the claims embodying those two separate, individual, completed stages or steps, it follows that any process which makes concentration an intermediate and completed step, one that precedes final and effective cyaniding, is a process different from the one Brown disclosed and claimed. * * * The defendants, in common with Brown, it may be conceded, are using the cyanide solution in the earlier stage of their process, and to that extent we may say initially utilize the general chemical treatment incident to cyaniding, preparatory to concentrating. But beyond this the resemblance ceases, for by defendant's process concentration * * * is the initial and intermediate step in their process."

## Company Reports

The seventh annual report of the **Goldfield Consolidated Mines Co.**, for the calendar year 1913, gives the following data on operation: The mines produced 349,465 tons of ore, of which 330,217 tons of an average gross value of $14.88 per ton was milled, and 19,248 tons of an average gross value of $27.39 per ton was shipped. The total gross value was $5,438,853. Deducting metallurgical losses, smelter discounts and the cost of a small tonnage purchased, an aggregate of $496,025, the value realized from the year's operations was $4,942,828. Expenses of mining, milling, transportation, construction, taxation and general expense amounted to $2,210,883, leaving a net realization of $2,731,945. Operating cost per ton was 54 cents lower than for the previous annual period. Two dividends were paid during the year, one for 30 cents per share and one for 40 cents, aggregating $2,491,404. At the close of the year the company's cash balance is $1,074,372, with bullion and miscellaneous products settlements outstanding of $161,217. The net realization from operation was 50.23 per cent of gross value of ore.

The report contains many detailed costs of operation, from which we take the following:

### Segregaton of Milling Costs

*Per Ton of Ore Milled*

| Department | Labor | Supplies | Power | Total | % Total |
|---|---|---|---|---|---|
| Crushing and conveying... | $.017 | $.008 | $.005 | $.033 | 2.08 |
| Stamping | .032 | .028 | .065 | .125 | 7.73 |
| Chilian milling | .018 | .033 | .046 | .097 | 6.07 |
| Elevating and classifying.. | .012 | .004 | .006 | .022 | 1.36 |
| Tube milling | .014 | .101 | .107 | .222 | 13.93 |
| Concentration | .040 | .007 | .016 | .063 | 4.00 |
| Neutralizing | .007 | .048 | ... | .063 | 3.46 |
| Settling | .013 | .049 | ... | .062 | 3.86 |
| Dissolution | .021 | .363 | .034 | .418 | 26.23 |
| Filtering | .038 | .025 | .013 | .076 | 4.78 |
| Tailing expense | .001 | ... | ... | .001 | .09 |
| Assaying | .003 | .019 | ... | .022 | 1.39 |
| Precipitation | .008 | .055 | .012 | .075 | 4.68 |
| Refining | .023 | .041 | ... | .064 | 4.05 |
| Water | .005 | .066 | ... | .071 | 4.47 |
| Surface and plant | .011 | .005 | ... | .016 | .97 |
| Steam heating | .003 | .007 | ... | .010 | .60 |
| Storehouse and office | .012 | .003 | ... | .015 | .94 |
| Stable | .001 | .001 | ... | .002 | .12 |
| Watchmen | .024 | ... | ... | .024 | 1.52 |
| Superintendence and foremen | .059 | ... | ... | .059 | 3.72 |
| Lighting | .002 | .002 | .014 | .018 | 1.22 |
| General expense | .003 | .005 | .001 | .009 | .55 |
| Mill tools | .001 | .001 | ... | .002 | .07 |
| Electrical department | .003 | .003 | ... | .006 | .33 |
| Pumping battery water | .005 | .002 | .015 | .022 | 1.34 |
| Experimental | .005 | .002 | ... | .007 | .44 |
| Totals | $.381 | $.878 | $.337 | $1.596 | 100.00 |
| Per cent of total cost of milling | 23.90 | 54.99 | 21.11 | 100.00 | |
| Per cent of combined cost of milling and concentrate treatment | 19.35 | 44.59 | 17.12 | 81.06 | |

### Segregation of Concentrate Treatment Costs

*Per Ton of Concentrate Treated*

| Department | Labor | Supplies | Power | Total | % Total |
|---|---|---|---|---|---|
| Raw cyanidation | $.095 | $.561 | $.185 | $.841 | 15.11 |
| Filtering and conveying | .230 | .045 | .040 | .315 | 5.66 |
| Roasting | .223 | .529 | .102 | .854 | 18.03 |
| Acid treatment | .118 | .403 | .173 | .694 | 14.65 |
| Tube milling | .028 | .018 | .043 | .089 | 1.87 |
| Cyanidation of roasted product | .085 | 1.077 | .138 | 1.300 | 27.42 |
| Assaying | .016 | .127 | ... | .143 | 2.57 |
| Precipitation of copper | .024 | .002 | ... | .026 | .54 |
| Precipitation | .014 | .091 | .019 | .124 | 2.23 |
| Refining | .038 | .069 | .001 | .108 | 1.93 |
| Disposal of tailing | .026 | .017 | .008 | .051 | 1.07 |
| General expense | .015 | .011 | ... | .026 | .47 |
| Handling dump | .065 | .010 | .002 | .077 | 1.63 |
| Water | ... | .323 | ... | .323 | 6.82 |
| Totals per ton of concentrate | $.977 | $3.283 | $.711 | $4.971 | 100.00 |
| Totals per ton of ore | 0.72 | .248 | .053 | .373 | |
| Per cent of total cost of concentrate treatment | 19.65 | 66.04 | 14.31 | 100.00 | |
| Per cent of combined cost of milling and concentrate treatment | 3.66 | 12.59 | 2.69 | 18.94 | |

The report states that experiments are being continued looking toward means of successfully treating large quantities of low-grade ore that cannot now be mined and treated at a profit. No process has yet been devised to meet this need. In regard to tailings that have been impounded since the beginning of operations, careful experiments have shown that this material can be subjected to further treatment at a profit of a few cents per ton. Plans for equipment to handle the tailings are practically complete, and will be executed at the proper time. About five years' time will be required to treat the accumulation.

The constituent companies of **Phelps, Dodge & Co.** enjoyed uninterrupted operations during 1913, and produced more copper than in any previous year, according to the annual report for that period. Copper ores mined amounted to 1,978,892 tons, of which 1,122,372 tons was concentrated and the balance smelted direct. The quantity of copper produced was 155,665,712 lb., containing 31,141 ounces gold and 1,870,162 ounces silver. Details of operation of constituent companies are as follows:

The reduction works department of the **Copper Queen Consolidated Mining Co.** treated 1,193,726 tons of copper-bearing material, producing 133,410,592 lb. copper, 1,870,162 ounces silver and 31,141 ounces gold. Experiments on dust losses from the large steel stack showed that copper loss had been reduced from a daily average of 14,310 lb. in 1909 to 2286 lb. in 1913, with practically the same number of furnaces and converters in operation. The two tests were taken in the same month and under similar weather conditions. In the blast-furnace department the flue dust produced was 3.92 per cent of the charge, as against 5.9 per cent in 1912 and 7.59 per cent in 1911. Furnace charge per day was 343.5 tons, of which 12.4 per cent was coke. Matte fall was 18.79 per cent. In the reverberatory department the McDougall roasting furnaces produced 56.5 tons of calcines per furnace per day, and flue dust to the extent of 5.2 per cent of the charge. Reverberatory furnaces smelted 289.6 tons per furnace per day. Oil consumption was 0.9 bbl. per ton of charge, of which 34.57 per cent was charged to steam and credited to reverberatories. Basic lined converters were used entirely throughout the year, treating 206,493 tons of matte and producing 67,256.6 tons of bullion from an average of 6.5 stands per day. In the power plant the cost per horse-power for the year was $54.844, and the average daily horse-power developed was 4595.8.

"During the year an experimental plant was completed, and experiments were conducted principally with the view of determining the best method of leaching low grade ores and the tailings from the concentrators. A Wedge furnace, of the muffle type, was erected, which produced calcines containing a very high proportion of their copper soluble in water, and practically all of the remainder soluble in dilute acid, but with a high fuel consumption.

"The recovery of the dissolved copper was effected by electrolysis, using graphite anodes, and reducing the resistance and increasing the yield of sulphuric acid, by injecting sulphur dioxide into the electrolyte. The results were favorable, but several problems which presented themselves, as the experiments progressed, remain to be solved, as well as a reduction of the high fuel consumption, before definite conclusions can be reached."

**The Detroit Copper Mining Co. of Arizona** reports the treatment of 537,324 tons of copper-bearing material during 1913, with a yield of 22,255,130 lb. of copper bullion, at a rate of 41.42 lb. of refined copper per ton of ore. The average grade of all ore mined was 2.9 per cent copper, compared with 3.25 per cent for 1912. Concentrating ore averaged 2.78 per cent copper, compared with 3.08 per cent for 1912.

Concentrating operations are epitomized as follows:

| | |
|---|---|
| Ore concentrated, 517,518 tons, assaying | 2.785% cu. |
| Concentrates produced, 66,928 tons, assaying | 15.834% cu. |
| Savings—Ore and concentrates | 73.52% |
| Ore and tailings | 75.18% |
| Concentrates and tailings | 74.76% |
| Assay only | 75.27% |
| Tailings assay | .79% |
| Tons ore milled per ton concentrates | 7.73 |
| Actual running time to total time | 95.46% |
| Ore milled per 24 hours actual running time | 1485.14 tons |
| Water used per ton ore milled | 554.98 gal. |

The smelting plant has been thoroughly overhauled and basic converting has replaced acid practice. At the power house a new boiler, steam turbine, Nordberg compressor and condensing plant were installed. A new furnace, flue, dust chamber and furnace building were erected.

Concentrator operations of the **Moctezuma Copper Co.** were as follows:

| | |
|---|---|
| Ore milled | 603,654 tons, dry weight, assaying 3.557% cu. |
| Concentrates produced | 135,057.331 tons, assaying 13.376% cu. |
| Tailings produced | 468,596.669 tons, assaying 0.67 % cu. |
| Saving (average, four methods of figuring) | 85.0% |
| Ratio of concentration | 4.469 |
| Tons of ore milled per day, actual running time | 1743.729 |
| Fresh water used per ton of ore milled | 1020.721 gal. |

The cost of milling was slightly higher than in 1912, due to changes and repairs made in the mill.

**The Burro Mountain Copper Co.** reports an addition of about 50,000 tons of 2.35 per cent copper ore to known reserves. A favorable site for a concentrator of 1000 tons daily capacity has been chosen about 3 miles easterly from Tyrone. A central power plant, equipped with two 1000-hp Diesel engines, will be situated at Tyrone.

The fifteenth annual report of the **American Smelting & Refining Co.**, covering the calendar year 1913, shows that after charging off $1,525,518 for depreciation of property, and paying the usual dividends on preferred stock, the surplus income for the year was $3,736,541, of which $2,000,000 was paid to holders of common stock. The earnings from smelting and refining works and from mines are $3,570,532 less than during 1912. This decrease arises largely from the fact that ore mined from the company's properties, and awaiting transportation facilities, is valued only at cost of mining. A large credit of this character has been deferred awaiting normal conditions.

The company carries on its pension fund forty employees whose days of usefulness have passed. The income from the pension fund exceeded payments during the year by $10,395.

To promote fair treatment and cordial relationship between the company and its employees, the services of Hon. C. P. Neill, formerly Labor Commissioner of the United States Government, under the Roosevelt, Taft and Wilson Administrations, were secured in May, 1913, and the welfare work, hospital arrangements and employer's liability settlements of the company have been placed under the supervision of a committee, of which Mr. Neill is chairman.

## The Iron and Steel Market

April has been a month of negative rather than positive developments in the iron and steel trade. The dullness which began late in February and reached an acute stage in March was almost universally expected to give way to more active conditions in April, a month marking the general inception of outdoor work and also a time by which the stocks accumulated by reason of the fairly heavy buying of January and early February should be exhausted.

The month, however, brought no improvement whatever in the iron and steel markets. In most quarters the feeling has been, on the contrary, that a great deal of ground has been lost. Close analysis indicates that there has been less of actual loss than there has been failure to attain what was expected. The current concepts of the state of trade are colored in pessimistic vein. This is illustrated by the fact that the rate of operation of the steel mills is frequently stated in current talk at less than the actual rate. There is excellent ground for an estimate that the steel industry as a whole has operated during April at fully 65 per cent of its full capacity, whereas statements have sometimes been made, and have gained considerable credence, that the industry has not been operating at more than 50 per cent. The reduction in mill activity has therefore not been large, for it is doubtful whether at any time in February a rate of more than about 75 per cent was attained.

The course of steel prices has been downward, though not radically so. A very low level was reached in December, forming the basis of the buying movement which began in that month and hardly lost its force until February was well advanced. Prices rose but slightly, and they have correspondingly declined but slightly, the level to-day being substantially the same as at the recent low point.

The outlook is extremely difficult to discern, and opinions now expressed by usually competent judges seem to be colored largely by individual temperament. Thus there are those who view the low rate of buying, a rate even below the lessened rate of producing and shipping, and conclude that the trade is booked for worse times, lower prices and lesser production than has yet been seen, while there are those others who reason that the buying has been abnormally low, below the actual rate of consumption, that everything bad has been "discounted' and that the market cannot grow worse. Hence they insist it must grow better.

For a time the steel industry embraced the view that a decision in the eastern freight rate case (now expected for about the middle of May) or possibly even an unfavorable decision, would be followed at once by a very considerable expansion, through buying not simply by the railroads but by other consumers as well, but lately this view has been in process of abandonment. The inception of spring has brought no improvement, and now hopes are beginning to center upon crop prospects, which are favorable and which are expected to become the subject of more detailed and precise information and prediction as the weeks pass. It is admitted at last that no improvement such as would operate the steel industry at capacity can possibly occur before September or October, while as to operations in the next two months the chances are about even for an increase or a decrease.

### Pig Iron

Transactions in pig iron were very light in April, lighter even than in March. In many cases consumers reduced their requisitions against contracts, and such action coupled with extremely light buying has placed the furnaces in less comfortable position. Furnacemen have not, however, displayed any disposition to cut prices, their firmness in such circumstances being rather unusual. The American Pig Iron Association, formed January 8, may be partly responsible for the indisposition to cut prices, since while the association involves nothing by way of price agreement it has done much towards disseminating information as to production costs, which are alleged to be above selling prices, and has thus encouraged sellers to avoid cutting. Price changes in the month include advances of 50 cents at Cleveland and 25 cents at Buffalo and a decline of 25 cents in the southern market, so that the average level of prices is substantially unchanged, being, however, nearly 50 cents a ton above the low point late in January. Current prices are as follows: No. 2 foundry, f.o.b. Birmingham, $10.50; delivered Philadelphia, $15; f.o.b. furnace, Buffalo, $13.50; delivered Cleveland, $14.25; f.o.b. furnace, Chicago, $14.25; at valley furnaces (90 cents higher delivered Pittsburgh): Bessemer, $14; basic, $13; malleable, $13 to $13.25; No. 2 foundry, $13.25; gray forge, $12.75.

### Steel

As forecasted in the report a month ago, the billet and sheet bar market has failed to advance $1 a ton as of April 1 through mills having been quoting $21 on billets and $22 on sheet bars for first quarter, and $1 advance over these figures for second quarter delivery. On the contrary, the highest that could be quoted as the market is $21 for billets and $22 for sheet bars, at maker's mill, Pittsburgh or Youngstown, while it is believed in many quarters that these figures could be shaded $1 a ton on any active inquiry. There has been no demand, however, and it is evident that mills covered quite generally for second quarter as well as first quarter when the market was at about $20 for billets and $21 for sheet bars, late in December and early in January. Forging billets are $25 to $26 and rods $26, Pittsburgh.

### Finished Steel

Finished steel products have shown a declining tendency. Plates, shapes and bars have definitely dropped to 1.15c, and even relatively small lots can be secured at this level, which represented the extreme of the decline in December. Steel pipe was reduced one-half point, or about $1 a ton, through the new card issued April 20 by the National Tube Company, this change restoring the discounts in effect prior to the half-point advance of February 2. Line pipe was likewise reduced April 20. The sheet market has steadily softened.

Prices named below are f.o.b. Pittsburgh, unless otherwise stated:

Rails, standard sections, 1.25c. for Bessemer, 1.34c. for open-hearth, f.o.b. mill, except Colorado.

Plates, tank quality, 1.15c.

Shapes, 1.15c.

Steel bars, 1.15c., base.

Iron bars, 1.30c., Pittsburgh; 1.22½c., Philadelphia; 1.12½c., Chicago.

Wire nails, $1.60 per keg, base; plain wire, 1.40c., base.

Sheets, blue annealed, 10 gage, 1.40c.; black, 28 1.85c. to 1.90c.; galvanized, 28 gage, 2.85c. to 2.90c.; painted corrugated, 28 gage, 2.05c. to 2.10c.; galvanized corrugated, 28 gage, 2.90c. to 2.95c.

Merchant steel pipe, ¾ to 3 in., 80 per cent off list.

Steel boiler tubes, 3½ to 4½ in., 71 per cent off list.

Standard railroad spikes, 1.40c. to 1.45c., Pittsburgh; 1.50c., Chicago.

Structural rivets, 1.70c.; boiler rivets, 1.80c.

Cold rolled shafting, 64 to 65 per cent off list.

---

## The Possibilities of St. Louis as a Field for Electrochemistry

Mr. C. F. Carrier, Jr., of the firm of Lawrence & Carrier, Inc., consulting chemical engineers of St. Louis and Memphis, lectured on the above subject on April 14 before the League of Electrical Interests in St. Louis in a most interesting manner.

He first sketched to what extent electrochemical industry already exists in St. Louis. "Electroplating is already old and will increase or diminish from other than electrochemical reasons. The laundries are making some bleaching liquor on a small scale for their own use by passing direct current through a solution of common salt. One plant for the production of oxygen and hydrogen gas is already in operation and a second one will be in use in the very near future. Sporadic attempts have been made to use the electric furnace for steel and brass, but it is only recently that a real steel furnace has been contemplated and will very soon be in operation.

"The location of an electrochemical enterprise is, of course, governed by the same general principles that apply in the location of any industry. The final test is will it pay? The most prominent factor is the power cost, but in many cases the less obtrusive factors have not been given due emphasis. Power is never the whole cost and in many cases industries classed as electrochemical, this factor will be less than 25 per cent of the manufacturing cost. It is but natural to contrast our situation with Niagara Falls and New York, the two great electrochemical centers of the country and see to what extent the various factors have determined the fixing of certain industries at these points.

"The first Niagara power was delivered August 26, 1895, and the power company was confronted with the problem of disposing of the largest single block of power that had ever been put on the market at one time. They soon found that the regular industries of the district would never be able to absorb so much power; therefore it became necessary to offer power at extremely low rates in order to stimulate the creation of new industries that could use large blocks of power. The effort was successful, and we now see the great industries that have made Niagara the great electrochemical center of the world. This power was offered at rates with which St. Louis can never hope to compete, but at the present time this power has been almost entirely absorbed, and the tendency of the rates has been steadily upward. There is still a small amount of power to be had right at Niagara Falls at rates somewhat better than are offered here in St. Louis, but the difference is rapidly disappearing and we find that at Buffalo the rates are really higher, as shown by contract forms from Buffalo and St. Louis in my possession and the terms of contract are favorable to St. Louis, as the Buffalo contract stipulates such a high rate during the peak hours that the average price per kilowatt for 24-hour service would be materially increased.

"For large blocks of power with a high load factor a very good rate can be obtained in St. Louis. An electrochemical plant would operate 360 days per year, and under proper management should be able to maintain a load factor of 85 per cent. On a basis of 50 kw the net cost per kilowatt hour in St. Louis for prime power would be 7¼ mills. This figure only applies to large blocks of power with a high load factor such as would be the condition in an electrochemical plant. For larger loads an even better net cost is obtainable. For other manufacturing purposes the power rates at practically all points in the country are on a competitive basis with steam-driven plants, and owing to its cheap supply of fuel St. Louis has a great advantage over Buffalo.

"The figures discussed above are based on power purchaser from central stations. It will be interesting to know what can be done with the isolated plant. Central station managers have been slow to realize what extremely economical results have been obtained in the power plants of some of the electrochemical plants, especially in the copper refining industry. Near New York City, with coal costing more than 100 per cent higher than at St. Louis, plants of over 10,000 kw are delivering power at the switchboard, and this is refined power direct current, at 6 mills per kilowatt-hour. This figure can nearly be duplicated at East St. Louis with a 1000-kw plant operating 360 days per year with an 85 per cent load factor and a 10,000-kw plant would give a figure of 5 mills. Such a plant is not a chimera, for there are single electrochemical industries taking from 10,000-40,000 kw.

"The central station manager has also been slow to realize the possibilities of adjusting a heavy off-peak load to balance the load factor of the station. An electrochemical plant having a normal demand of 1000 kw could be arranged to take 25-35 per cent overload during the off-peak hours. Practically every station has a large amount of idle apparatus during at least 16 hours per day, and usually longer. This power, taken only above the normal demand and only during off-peak hours, could be sold profitably at a very low price, and the effect would be to raise the load factor of the power plant and to diminish the net cost per kilowatt-hour to any consumer who could meet the load conditions specified, say a load factor of over 80 per cent.

"Those industries in which the cost of power is an overwhelmning factor in the cost of production must of necessity go to the cheap power. Nitric acid is made from the atmosphere in Norway by high-tension electric arcs, and pig iron is made in California in an electric furnace, but even Niagara cannot compete with either. Calcium carbide, carborundum and graphite are for the time at least beyond the reach of St. Louis competition, and we shall probably continue to see aluminum oxid made in East St. Louis shipped to Niagara and Massena Falls and the finished metal shipped back to St. Louis, but this does not prove that there is no hope for St. Louis in the electrochemical field.

"When the ratio of power cost to selling price begins to diminish, as is the case with many of the other electrochemical products, the increasing importance of other factors will soon counterbalance even a substantial power cost difference, should such exist. A few examples will show this very clearly; 70 per cent of the world's production of copper is refined in the New York manufacturing district with steam power that in times past at least has been 50 per cent higher than at Niagara. Electric steel is being made in all parts of the world with energy from all types of prime movers and at prices ranging from $10-$150 per horsepower per year. Most of the electrolytic caustic soda and bleach made in Europe is with steam-driven power plants, and there are two such plants within a few miles of New York City operating profitably and using power that costs over 100 per cent higher than the St. Louis central station rate for the same power conditions.

"Assuming caustic soda to be manufactured at St. Louis, about 25-35 per cent of the manufacturing cost will be power. This cost would be approximately $20 per ton of finished caustic, charging all the power to the one product. At the rates which the caustic plants were able to obtain at Niagara when they started, the advantage would be about $9 per ton against St. Louis. This puts the situation in the most unfavorable light possible, but even so, competition is well within the bounds of commercial possibility. Cheaper fuel for evaporation of the product amounts to $1.50, the saving by distributing locally in tank cars instead of reducing to a solid saves $3 in containers, labor and fuel, lower freight to natural market might amount to $3-$5 per ton, hence there is a large natural market within the bounds of which a St. Louis plant would have a substantial advantage over Niagara and Michigan points.

"One of the most alluring fields for St. Louis is in the melting of steel, copper, brass and other alloys."

Among other electrochemical possibilities Mr. Carrier mentioned that St. Louis alone purchases upward of $50,000 worth of barium peroxide per year from England, yet St. Louis has barium sulphate rock almost at its door. This can be reduced to over 90 per cent soluble condition in an electric furnace, while only 60 per cent becomes soluble in a fire furnace. The author concluded with the expression of his firm belief in the electrochemical possibilities of St. Louis.

---

**The production of aluminium ore** in the United States in 1913 amounted to 210,241 long tons, valued at $997,698. This is an increase of 31.5 per cent in quantity and 29.8 per cent in value as compared with 1912. Alabama, Arkansas, Georgia and Tennessee were the producing states.

# The Development of Copper Leaching and Electrolytic Precipitation at Chuquicamata, Chile[1]

BY E. A. CAPPELEN SMITH

The Chuquicamata copper mine is located at Chuquicamata, a station on a branch of the Antofagasta and Bolivia Railroad, in the Province of Antofagasta, Chile, between 22 and 23 degrees South latitude. Chuquicamata is 165 miles by railroad from Antofagasta, and 82 miles in a straight line from the coast and lies at an altitude of 9500 ft. above sea level.

The deposit has long been known as the atacamite deposit of Chile, and for many years past has been mined by the natives. As evidence of their operations we find in the old workings many stone utensils, hammers, etc.—and mummies.

The deposit is a brochantite mineral contained in the cleavages of the granodiorite, mixed in part with chalcanthite and to some extent with atacamite, and with a deposit of salt. A small amount of caliche containing nitrates is also present in the upper layers of the ore-body.

The so-called Llampera ore body extends for a distance of approximately 8,000 ft. with an average width of about 500 ft. Throughout the whole length of the deposit numerous tunnels have been run and a very large quantity of ore has been left on the dumps from these tunnels. From the tunnels raises have been made almost to the surface, leaving in places a shell over the workings 8 to 12 in. thick. A few shafts have also been sunk in the ore deposits, the deepest one to a depth of 110 meters.

## Acquisition and Development of the Property

The property was acquired by Mr. Albert C. Burrage of Boston, who, in connection with the firm of Messrs. M. Guggenheim's Sons, formed the Chile Exploration Company, which company now owns the property.

The property has been explored by churn-hole drilling. The drilling has developed an ore-body in excess of 200,000,000 tons. Most of the drill holes, however, were stopped while the bottom of the hole was still in ore.

The general direction of the ore body is north and south. Lately a number of drill holes have been sunk at a considerable distance west of the Llampera, and after going through from 300 to 400 ft. of capping, chalcocite and chalcopyrite have been encountered, giving indications of a very materially increased tonnage over that reported up to date.

In the Llampera zone, of the 200,000,000 tons of ore so far developed, approximately two-thirds is brochantite and one-third sulphides. No change in the formation has been shown, even in the deepest drill holes, the ore still appearing to be in the cleavages of the granite. The lower drill holes show primary ore. From the amount of ore developed and indicated, it appears that the Chuquicamata mine is probably the largest copper deposit known to-day.

It was generally assumed that this large and well-known deposit of ore was atacamite, and as such could not be treated at a profit by any of the established methods; first, on account of the highly siliceous nature of the ore and the absence of sulphides and water, and, secondly, on account of the volatilization in smelting of the copper chloride.

It was demonstrated that the mineral was not atacamite (oxy-chloride) but brochantite (oxy-sulphate) and that mixed with the brochantite in the upper parts of the ore-body was a deposit of salt. The brochantite, being an oxy-sulphate of copper, is insoluble in water but very readily soluble in dilute sulphuric acid. It was, therefore, evident that the way to treat the brochantite ore-body would be by wet methods.

## Preliminary Experiments

About 600 tons of the oxidized ore, representing, as near as we can judge, a fair average of the oxidized ore-body, have been shipped to New York for experimentation on a small scale.

At first tests were run on a very small scale and gradually, as promising results were obtained, on a somewhat larger scale, treating about 2 tons of ore per day. The average content of the ore thus treated was somewhat in excess of 2 per cent in copper.

The main problems which presented themselves for solution were:

1. The solubility of the copper minerals in sulphuric acid.
2. The amount of chemicals required as a dissolving agent.
3. The amount of impurities which would enter the solutions, and
4. The precipitation of the copper from the solutions obtained.

The principal developments in the solving of these problems may be briefly summarized as follows:

1. **Solubility of the Mineral**—Experiments conducted on a small scale disclosed the fact that the copper-bearing mineral was very readily soluble in a cold dilute sulphuric acid solution and that only comparatively coarse crushing would be required.

2. **Chemicals Required**—After prolonged experimentation, it was found that the ore yielded enough sulphuric acid, from the decomposition of the copper sulphate present in the brochantite, to more than make up the losses in sulphuric acid in the operation. The losses of acid occur mainly in two stages: first, the loss due to dissolving other components besides copper from the ore; and, second, due to wasting of solutions through discarding of the residues.

3. **Impurities Entering the Solutions**—Experimentation extending over a long period of time has shown that no deleterious amount of impurities will accumulate in the solution, other than the chlorine derived from the salt deposit mixed with the mineral in the upper parts of the ore body.

4. **Precipitation of the Copper**—The experiments conducted in our experimental plant have shown conclusively that electrolytic copper of the highest grade can be produced from the sulphuric acid solutions obtained.

## Experimental Leaching

After completing a number of leaching tests on a laboratory scale, and after running a number of tests each with 100 kilos of material, experimentation was inaugurated on a larger scale and a plant was built of sufficient size to treat two tons of ore per day.

In this plant there have been treated 131 charges of ore and the plant has been run entirely as a self-contained unit—leaching the ore, washing it, purifying and electrolyzing the solutions obtained, and leaching the following lots of ore with the electrolyzed solution from previous charges.

In this plant were treated ores representing the general character of the oxidized ore body at Chuquicamata; some high in copper, others low in copper; some high in impurities, others low in impurities, and enough runs were made to prove the method on both high and low-grade ores, and on ores containing large amounts of salt as well as smaller amounts of salt, this being the principal impurity in the ore-body. The salt deposit, however, is confined to the upper 50 ft. of the ore-body and principally to the first 25 ft.

---

[1] A lecture delivered at the 25th General Meeting of the American Electrochemical Society, Columbia University, New York City, April 18, 1914.

In order to make sure that the method should be tested under the most adverse conditions, the same solution was used over and over again for the treatment of the before-mentioned 131 charges of ore, only setting aside enough solution to allow for the excess acid. A complete analysis of this solution was then made and showed the following contents:

| | Grammes per litre |
|---|---|
| Cu | 50.44 |
| Fe | 3.71 |
| Mn | 0.07 |
| P | 0.06 |
| As | nil |
| Sb | nil |
| CaO | 0.80 |
| MgO | 3.32 |
| $Al_2O_3$ | 1.61 |
| $Na_2O$ | 21.60 |
| $K_2O$ | 5.00 |
| $SO_3$ | 122.75 |
| Cl | 11.52 |
| Free acid (as $H_2SO_4$) | 28.00 |
| Total solids on ignition | 189.40 |
| Nitric acid | 4.00 |

The results obtained when using the solution which had previously treated 131 charges of ore were just as good as the results with the solution made from sulphuric acid and water. In other words, the accumulation of impurities has been proven to have absolutely no effect whatever on the results of the leachings obtained. The average extraction obtained in this 2-ton plant was 90.99 per cent.

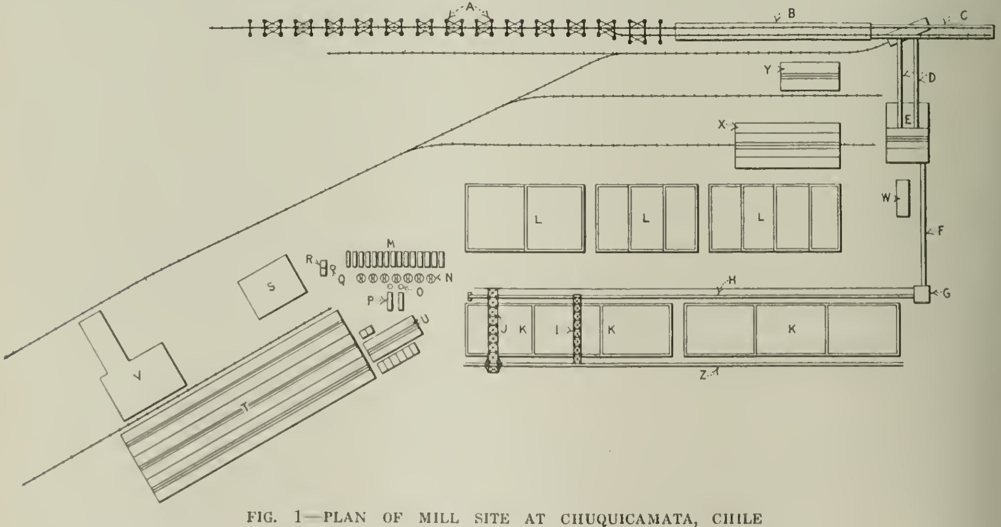


FIG. 1—PLAN OF MILL SITE AT CHUQUICAMATA, CHILE

**Key to Drawings**

A—Approach trestle.
B—Ore bin.
C—Gyratory breaker house.
D—36-in. belt conveyors.
E—Crusher house.
F—36-in. belt conveyor.
G—Sampling bin.
H—36-in. belt conveyor.
I—Filling bridge.
J—Reclaiming bridge.
K—Leaching vats (6)
L—Solution sumps (9).
M—Dechlorinating drums (21).
N—Settling tanks (7).
O—Montejus (2).
P—Filter presses (2).
Q—Reservoir from settling tanks.
R—Pumping plant to tank-house head tank.
S—Tank-house head tank.
T—Electrolytic tank-house.
U—Main pumping plant.
V—Substation.
W—Transformer station.
X—Machine shop.
Y—Warehouse.
Z—Tailings conveyor, 36 in.

Following the experiments in the 2-ton plant, a leaching tank was built of concrete, lined with mastic asphalt, having a cross section of 4 ft. x 6 ft. and 15 ft. deep, holding 15 tons of ore, this allowing the use of the full height of ore column since adopted for the plant now building at Chuquicamata. The question to be decided was whether it was feasible to leach the ore in tanks of this depth. Extensive experimenting gave results confirming those obtained in the smaller tanks.

A wooden filter-bottom with cocoa-matting on top has been employed in the 2-ton tanks and in the 15-ton tank, although a great number of leachings were made without any filter-bottom, simply placing a piece of cocoa-matting over the out-flow pipe.

All leachings were made without applying any extraneous heat.

The washing of the ore was by the so-called "piston" method, with a final water-wash, and the tailings, or residues, discharged contained an average of about 12 per cent moisture, and about 0.04 per cent water-soluble copper.

### Extractions Obtained

The leaching results obtained up to date are as follows:

| | |
|---|---|
| The average extraction while treating the ore in lots of 100 kilos each was | 90.62 per cent |
| The average of 131 charges treated in the 2-ton plant shows an extraction of | 90.99 per cent |
| The average extraction obtained in the 15-ton tank, while treating 25 charges leached up to date, has been | 90.96 per cent |

These results being based on the weight and sampling of the ore as charged into the tanks and the weight and sampling of the residue discharged from the tanks.

By combining all of these leachings and taking the copper contents based on the weight and sample of the ore treated, as against the copper produced in the electrolytic tanks in the form of cathode copper, together with the copper held in solution as copper sulphate, the extraction was 89.6 per cent. The small discrepancy is accounted for by solutions, of which no account has been taken, which have been removed for special tests, as well as spills which will necessarily occur in operating a small scale plant.

### Amount of Chemicals Required

After having supplied the amount of sulphuric acid required to start the operations, it was found that not only was no further acid required, but that excess acid was produced from the sulphuric acid contained in the ore itself, to such an extent that an actual gain is shown of approximately 9 pounds of acid ($H_2SO_4$) per ton of ore treated. In other words, it will be necessary to discard an amount of solution equivalent to this gain in acid in order to prevent the acid from accumulating in the process. This gain in acid was made while treating an ore averaging a great deal higher in salt than even the average of the upper layers of the ore body at Chuquicamata will show. As the greatest loss of acid is in forming sodium sulphate, I believe that a still larger gain in acid will be shown when treating the average ore body.

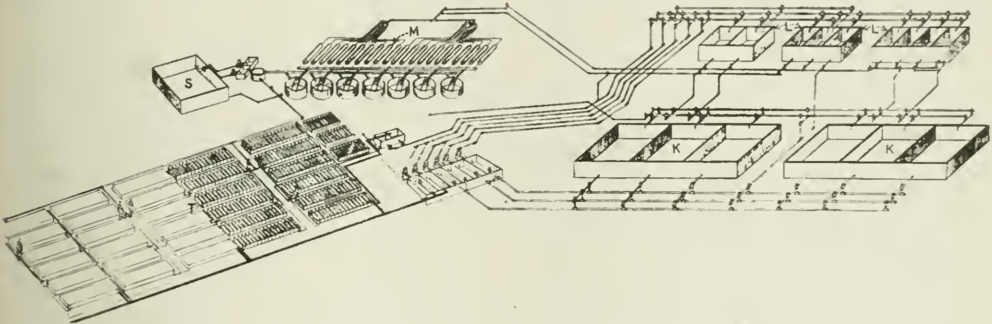


FIG. 2—PERSPECTIVE DIAGRAM OF LEACHING PLANT AT CHUQUICAMATA, CHILE

### Impurities in Solution

Of the impurities accumulating in the solution, the principal elements, outside of the chlorine present, are nitric acid, alumina, iron and alkali salts. After more than a year's work with the same solution, discarding only enough solution to take care of the excess acid, we find the following impurities present:

| | Grammes per litre |
|---|---|
| Fe | 3.71 |
| Mn | 0.07 |
| As | nil |
| Sb | nil |
| CaO | 0.80 |
| MgO | 3.32 |
| $Al_2O_3$ | 1.61 |
| $Na_2O$ | 21.60 |
| $K_2O$ | 5.00 |
| Nitric acid | 4.00 |

This amount of impurities is insignificant so far as effect upon the leaching and electrolysis is concerned.

The main impurity in our solution is the chlorine obtained from the salt in the upper part of the orebody. It was at first thought desirable to electrolyze direct the solution containing the chlorine and it was found perfectly feasible to do this in covered electrolytic tanks, maintaining a slight vacuum so that the chlorine gas was all drawn off through fans. However, it was also proven that only a part of the chlorine was eliminated in this manner and that an appreciable quantity was deposited with the cathode copper in the form, probably, of cuprous chloride.

### Elimination of Chlorine

Further experimentation proved that it was feasible to eliminate the chlorine from the solution by treatment with shot copper, the reaction resulting in the production of insoluble cuprous chloride. This precipitate settles readily.

Various methods of precipitating cuprous chloride were tried and finally shot copper, placed in a revolving drum, was adopted as the most satisfactory method. The cuprous chloride forming on metallic copper sticks tight to the copper shot, and it was found necessary to present continuously clean surfaces of copper in order to maintain an effective precipitation. After trying out several methods it was decided that the best apparatus for this purpose would be revolving drums similar to tube mills, through which the solution would be passed in contact with the shot copper contained in the drums, as in this way the copper, rubbing against itself, continuously presents a clean surface.

Precipitation with cuprous oxide gas also tried and worked very well except that the efficiency of the copper in this form as a precipitating agent, was found to be very much lower than that of metallic copper, even allowing for the theoretical difference.

The cuprous chloride produced may be treated in several different ways. It is our intention to filter-press the settled cuprous chloride, mix the filter press cakes with limestone and coke, and smelt the product thus obtained, producing metallic copper and calcium chloride as a slag. A number of experiments have been conducted with this mixture to establish the reaction, and it has been found that a very liquid slag of calcium chloride is produced containing a very small amount of copper, and that in this manner it is perfectly feasible to smelt the cuprous chloride without any loss by volatilization.

Some small scale experiments have also been made looking to the electrolytic treatment of the cuprous chloride and later on it may be possible that this latter method will be adopted, if found more profitable, in preference to the smelting method.

### Precipitation of the Copper

The solution, freed from its chlorine content, is now electrolyzed, using insoluble anodes and ordinary copper cathode starting sheets. After a vast amount of experimenting, we have decided to employ an insoluble anode made of magnetite. Various other anodes have been tried with more or less success, but after having investigated all the possibilities we have decided upon the magnetite anodes.

Experiments with these anodes have extended over about a year and a half, and we have found no material amount of chemical wear on the anodes. The magnetite anodes which we have adopted are manufactured by a secret process by the Chemische Fabrik Griesheim Elektron, of Frankfort, Germany. The nature of the material naturally gives a brittle anode. However, as it will not be necessary to handle the anodes after they are installed in the tanks, this is not a very decided drawback.

At first a number of difficulties were encountered in our efforts to secure an even current distribution and proper suspension of the anodes, but all of these obstacles have been overcome and we believe that a very serviceable anode has been developed.

The anodes themselves are hollow castings with a wall thickness of approximately ¼ in., and have a thin electroplated copper deposit on the inside.

As I am not myself familiar with the methods employed in the manufacture of these anodes, I am unable to give any further information on this point. I can only state that after months of continuous operation we have found the anodes entirely satisfactory for our purpose.

The copper cathodes produced from the electrolysis are of the usual quality of cathode copper—in fact, a little better—as in our particular case no arsenic or antimony, usually the most deleterious impurities in cathode copper, is present in the solution.

The solution will enter the head tank of the electrolytic system containing approximately 5 per cent copper and 2½ per cent to 3 per cent free acid, and will leave the last tank of the cascade containing about 1.5 per cent copper and 8 per cent to 9 per cent free acid. Within these limits it is always possible to produce a good hard cathode, equal to or better than the usual standard.

The electrolytic tanks used during our experiments are made of concrete, lined with mastic asphalt.

### Design of Plant now Building at Chuquicamata

On account of the very large ore body already developed at Chuquicamata the first unit of the plant now building has been designed to treat about 10,000 tons of ore per day. The electrolytic refinery will have a capacity of about 335,000 pounds of copper per day.

The ore will be mined by steam shovels, practically no stripping being necessary. The ore will be transported to the mill, distant about 2½ miles from the mine, in standard American gauge railroad cars of 60 tons capacity each.

Arriving at the plant, the ore will first pass through gyratory crushers, thence through 48-in. Symons disc crushers, and finally through Garfield rolls until a product is obtained of about ¼ in. mesh. The ore will be carried on conveying belts from the crushing plant, after sampling, to the leaching vats. Each of the leaching vats has the following dimensions, 110 ft. wide, 160 ft. long and 16 ft. high. The leaching vats, six in number, will be placed end to end.

The belt delivering the ore from the crushing plant will be discharged into the leaching vats with the aid of an electric traveling bridge, spanning and traveling the entire length of the leaching tanks. The leached and washed residue will be removed from the leaching tanks by a 15-ton grab bucket traveling on an unloading bridge and, after sampling, will be delivered onto a conveying belt for disposal to the tailings dump.

The tanks are being built of heavily reinforced concrete, and will be lined with mastic asphalt 1½ in. thick. This tank lining has been developed by the Vulcanite Paving Company of Philadelphia, and consists of a specially refined Trinidad asphalt mixture, to which is added crushed quartz or granite.

In our experimental plant, where this lining has been in use for considerably more than a year, both in the leaching and electrolytic tanks, absolutely no difficulty has developed—not even a single leak. We have tested the material at a temperature of 50 deg. C. without finding any signs of softening, and as this is far beyond the range at which we intend to operate tests at higher temperatures have not been made, although the temperature limit, so far as softening is concerned, will probably lie somewhere between 50 deg. and 70 deg. C.

Tests have also been made to try the strength of this material from a physical standpoint, and in one case a 250-pound cathode was elevated about 5 ft. above the bottom of the tank and then dropped in such a way that one of the sharp corners of the cathode hit the bottom of the asphalt-lined tank. In this case a piece of the lining about ⅛ in. thick and 2 ft. in diameter was broken away, and as far as we could see the tank lining was just as good as ever.

The material has been tested in strong and weak acid solutions and found to be absolutely unattacked.

From the bottom of the leaching tanks the solution will be removed through eight 6-in. openings equally distributed over the tanks. A filter-bottom, consisting of two layers of 2-in. planks with a layer of cocoa-matting between, will be employed. This filter-bottom will be raised 4 in. above the bottom of the tank.

For the main solution circuits, 9-in. and 16-in. lead-lined iron pipe will be used. Open-boot horizontal centrifugal pumps, made of type-metal, will be used for pumping the solutions. The pumps will have a capacity of 550 cu. ft. per minute, elevating to a height of 60 ft.

In the leaching plant the cycle of operation will require approximately six days, of which one day will be occupied in filling the tank, two days in leaching, two days in washing and draining and one day in discharging.

The solutions will be conducted to the leaching tanks by gravity from nine solution-storage tanks placed above the leaching tanks. The dimensions of these solution-storage tanks are as follows:

| | |
|---|---|
| Two tanks | 12 ft. x 130 ft. x 150 ft. |
| Seven tanks | 12 ft. x 70 ft. x 150 ft. |

From the strong-solution tank the solution will flow by gravity through the dechlorinating plant, consisting of twenty-one 30-ft. long by 4-ft. inside diameter revolving steel drums lined with earthenware. These drums will be half full of shot copper. From these drums the solution, containing the cuprous chloride in suspension, will flow to seven Dorr thickeners made of concrete and lined with mastic asphalt. The clear solution overflowing will travel by gravity to the electrolytic refinery, while the thickened cuprous chloride, together with approximately 1 per cent. of the original solution, will go to filter presses.

The electrolytic refinery will consist of 510 electrolytic tanks of the following dimensions: 19 ft. long, 3 ft. 6 in. wide, 4 ft. 10 in. deep. They will be made of concrete, lined with mastic asphalt, and will be set through the floor, having inspection aisles underneath and a concrete working platform between the rows of tanks. The tank-house will be of concrete and steel construction.

Of the 510 tanks, 30 will be used for making cathode starting sheets, and the balance, 480 tanks, will be used for electrolytic deposition of the copper from solutions. The tanks will be arranged in five electrical circuits, with 96 tanks to a circuit, and will be divided into 30 solution circuits, the solution in each circuit flowing through 16 tanks placed in cascade.

The anodes, made of magnetite, will be 5 in. wide, 2 in. thick and 4 ft. long, with five to a bar. The cathodes will be 3 ft. wide by 4 ft. deep.

The spent electrolyte, containing about 1.5 per cent copper, will be pumped back to the storage tanks to be used for leaching subsequent charges of ore.

The cuprous chloride from the dechlorinating plant will be smelted and cast into shot copper for use in the dechlorinating drums.

The power plant will consist of a primary power station at the coast, using oil-fired Babcock & Wilcox boilers driving four steam turbines, connected to four 10,000 kw. alternating current generators. The current will be transmitted 85 miles at 100,000 volts to a sub-station located at the mill-site. The sub-station for the electrolytic refinery will consist of seven motor-generator sets, each of 2,500 kw. capacity.

### Conclusion

It will be readily understood that a vast amount of experimental work has been conducted in order to arrive at a satisfactory solution of the problems before us in connection with the ores from Chuquicamata, and a great many negative results have been obtained as well as positive results. From fifteen to twenty young engineers have been continuously employed for more than a year on this experimental work, the experimentation going on steadily in three 8-hour shifts.

It has been our endeavor in conducting the experiments to operate each part of the apparatus on what we might term a cross-section scale of the plant to be erected at Chuquicamata. We have thus used a leaching tank with the full depth of ore column, the important point in leaching, and we have used the same material for filter bottoms as will be used in the large plant. We have had full size solution valves installed. In connection with the dechlorinating plant we built a full cross section drum. In the electrolytic tanks we have been operating with full size cathodes and anodes. In short the idea has been to approach in our experiments, as far as possible, operating conditions similar to those which we will have in the large plant.

I wish to take this opportunity to state that great credit for the results obtained should be given to the loyal and enthusiastic staff employed, and I will particularly mention in this connection Mr. C. A. Rose in charge of the experimental work at the plant, and his able assistants, Mr. Leonard M. Green, who, under Mr. Rose, has had charge of the leaching part of the experiments and who has developed the details of the leaching and washing system now adopted, and Mr. M. R. Thompson, who has had charge of the electrolytic part of the experiments.

---

**The Tulsa Spelter Company**, Sand Springs, Okla., had under construction in 1913 a 4000-retort plant. It is expected that operations will commence this month with 1600 retorts.

**Columbia University** has issued a pamphlet giving information regarding the new advanced courses in engineering and technical studies. From and after July 1, 1915, the Schools of Mines, Engineering, and Chemistry will become advanced or graduate schools, and candidates for admission will be required to show evidence of preliminary training equivalent to three years study in a college of scientific school of high rank.

## The Cost and the Advantages of Using Electrically Melted Ferromanganese

Electric steel furnaces of various types have found a new field of application in recent years, as they are being widely used in Europe to keep a molten supply of ferromanganese on hand at the converter plant. The use of molten ferromanganese instead of solid ferromanganese not only results in a saving of alloy, but makes the deoxidation more efficient and the steel better; and the cost of melting the ferromanganese electrically is more than counterbalanced by these advantages.

This method has been widely introduced during the last few years in Europe. The first plant to take up this practice in this country has been the Illinois Steel Company, which at its converter plant at Joliet, Ill., employs a 4-ton Heroult furnace to keep on hand a supply of molten ferromanganese from which 150 lb. are taken every seven minutes. It is the experience of this company that besides the saving in alloy there is a clear advantage in quality, the soft steel produced being decidedly better for wire purposes.

In Europe various types of electric furnaces have been employed for the same purpose, and the induction furnace has found particular favor in several plants. As very few exact figures have been published in the past on this subject the following results obtained in three European plants employing induction furnaces for melting ferromanganese should be of timely interest:

The three plants in question use for this purpose a 3-ton, 350-kw furnace, a 4-ton, 500-kw furnace, and a 4-ton 500-kw furnace respectively, all being of the three-phase, 50-period, three-ring Roechling-Rodenhauser type, the design of which is very well known to our readers.

In the plant using the 3-ton, 350-kw ferromanganese-melting furnace, some thirty to fifty tappings, ranging each from 90 to 120 kg (198 to 264 lb.), are made every twenty-four hours, depending upon the demands of the steel plant. For the first five weeks the average energy consumption, excluding the energy required for burning in the lining, was 721 kw-hours per ton for an output of 220 tons of ferromanganese.

To maintain the furnace hot during long intermissions 200 to 250 kw are required.

As a result of using molten ferromanganese, an average saving of 30 to 40 per cent of weight of ferromanganese required is recorded. With cold ferromanganese from 7 to 8 kg are used per ton of steel and during a year some 2100 tons of cold ferromanganese are required. With molten ferromanganese this amount is reduced to less than 1400 tons, representing a saving of more than 700 tons, which at $55 per ton represents a saving of $38,500 per year.

In one of the plants with a 4-ton, 500-kw furnace ferromanganese has been melted at the rate of 10 tons per twenty-four hours with an energy consumption of 750 kw-hours per ton. The furnace, however, is capable of melting a considerably higher tonnage of ferromanganese per day and when the demand of the steel works increases it may be expected that the specific energy consumption will be reduced.

At the same time the amount of ferromanganese used per ton of steel has been reduced at this plant from 7.5 or 8 kg (for cold metal) to 4 kg (for molten metal), which is a saving of from 45 to 50 per cent.

If the results of these two furnaces are used on which to base an estimate of the power requirement and savings to be expected in new installations, it seems safe to figure on a saving of 30 per cent in weight of ferromanganese and a power consumption of 675 kw-hours per metric ton of ferromanganese for a 3-ton furnace in regular operation. For burning in the lining and heating up a 3-ton furnace about 3500 kw-hours are required and a life of 12 weeks, or 84 days of twenty-four hours, may be expected for the lining. From these data a figure for an additional small power consumption may be deduced. As stated, all these figures refer to induction furnaces. It would be interesting to get for comparison data from arc-furnace installations.

The use of molten ferromanganese has, however, additional advantages which cannot be stated as easily in figures. Owing to the rapidity with which molten ferromanganese becomes distributed through a steel charge much time is saved owing to the fact that the steel may be teemed at once. Further low-grade ferromanganese, containing large percentages of fines, may be easily melted in an electric induction furnace.

That the quality of the steel is improved by the use of molten ferromanganese will be understood from the following considerations:

The deoxidizing effect is much stronger and more rapid than with solid ferromanganese, as the latter must first be dissolved and exerts a certain cooling effect.

As the ferromanganese is added to the steel while teeming, it does not come into contact with the slag, and rephosphorization by reduction of the phosphates in the slag is entirely excluded.

Frequent analyses in the three induction furnace installations in question have proved that the composition of the steel remains constant from the first to the last ingot for any one charge.

On account of the uniformity of the composition of each ingot due to the better distribution of manganese and also to the more complete deoxidation the steel "rolls" extremely well. It has been proven that a section which, when cold ferromanganese was used, could not be satisfactorily rolled with steel containing less than 0.4 per cent Mn, can, when molten ferromanganese is used, be rolled easily from steel containing only 0.29 per cent Mn.

The amount of ferromanganese per ton of steel can be considerably reduced on account of the certainty that the total amount of ferromanganese added is utilized and nothing is retained in the slag or remains undissolved in the steel.

The contents of the ladle can be poured at once whereas much time is saved and, moreover, the charge need not be so hot from start so as to be able to heat the ferromanganese to melting temperature. The liquid steel remains completely quiet, does not boil, and can be poured very satisfactorily.

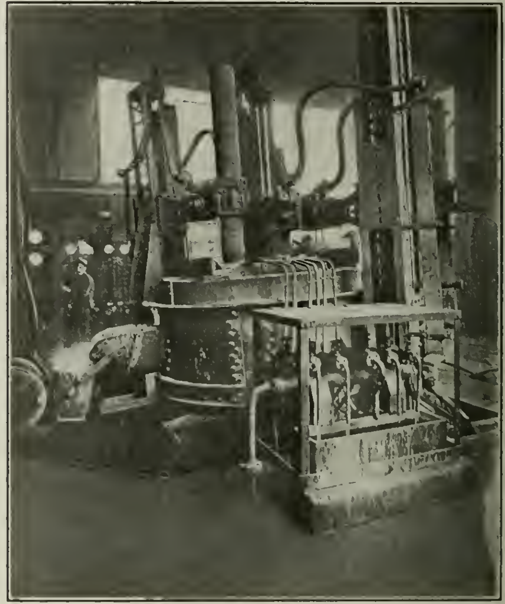
The lining is put into ferromanganese induction furnaces in about the same way as in steel furnaces; that is, a mixture of magnesite, or dolomite, with tar is rammed in hot. But because the temperature required is not so high as for steel and also because ferromanganese is usually in particularly convenient form for melting in an induction furnace, the life of the lining is much prolonged. From the results so far obtained it is thought possible when working continuously to average between four and five renewals per year, or even better.

No slag is required. The molten metal is effectively protected from oxidation by a layer of carbon in the form of petroleum coke. The metal being saturated with carbon, no alteration in composition occurs. The fact that such a covering is used proves that the atmosphere in the furnace is non-oxidizing.

While, as stated before, the Roechling-Rodenhauser type of combination induction furnace is used in the three installations here discussed, the Siemens & Halske Company, which made these installations, has developed more recently an improved type of induction furnace which combines the good points of the Kjellin, Roechling-Rodenhauser and Frick types and with which it has been possible to reduce the specific energy consumption still further.

* * * *

While the data given above from European practice refer to plants using induction furnaces for melting ferromanganese, other types of electric furnaces are also used for this purpose in Europe. The adjoining illustrations show a five-ton Girod furnace recently installed by the Friedrich Krupp A. G., Friedrich-Alfred Hütte, Rheinhausen-Friemersheim, Germany, for the melting of ferromanganese.



ELECTRIC FURNACE FOR MELTING FERROMANGANESE AT KRUPP PLANT

## Salt Lake City Meeting of American Institute of Mining Engineers

The one hundred and eighth meeting of the Institute will be held at Salt Lake City, Utah, August 10 to 14, 1914, inclusive. Local committees have been active in preparing for the entertainment and convenience of visiting members and an excellent technical program has been provided. Twenty-five papers have already been accepted for this meeting and others are expected. Authors are urged to have all papers in the hands of the secretary by May 15 if possible, and not later than May 31. Papers will be printed and distributed in advance to those members desiring to prepare discussions.

The social features of the Salt Lake City meeting will include visits to the neighboring mines and metallurgical works at Bingham Canyon, Garfield, Lark, Murray, Midvale, Park City and Tintic.

Adequate provision is being made for the comfort and entertainment of ladies, and a special committee has been organized to take care of this part of the meeting.

# Is There A Complex-Ore Problem?

## A Symposium on the Economics and Metallurgy of Mixed Base-Metal Sulphide Ores, Showing Present Status and Future Prospects of This Branch of Ore Treatment

A great deal is being said these days about "complex ores" and the "complex-ore problem," having reference to mixtures of base-metal sulphides and their profitable treatment. The impression prevails in some quarters that these ores are not amenable to present methods of treatment; that there are "millions of tons" of such ores; and that there is a distinct need for new treatment processes. In order to get a broad view of the real situation, and to ascertain to what extent the above impressions are correct, we invited a number of competent metallurgists and engineers to join in a symposium on the subject. The response has been gratifying, showing as it does a keen interest in the subject, and presenting a number of points of view. We give herewith a part of the contributions received and will present further views in our next issue. When all the views have been published we shall give a résumé of the situation as reflected from different engineers in various parts of the country.

In order to direct the line of inquiry we submitted a list of questions, which appear below, to serve as a general guide in approaching a subject which is admittedly broad and comprehensive. The reader will observe unanimity of opinion on some points, and diversity on others; all are interesting.

1. Is there a "complex-ore problem," and what, in your opinion, constitutes a "complex" ore?
2. Would such ores be amenable to present methods in the hands of skilled operators, or is there a need for new methods of treatment?
3. Do you believe there are many mines now idle which could produce a considerable tonnage of such ore if suitable methods of treatment were known?
4. What element or quality of such ores makes them refractory to present processes?
5. What methods or processes do you regard as probable solutions of the problem (mechanical, hydrometallurgical, electrometallurgical)?
6. To what extent would microscopical examination of such ores be of material assistance in suggesting proper methods of treatment?

**W. G. Swart:**—1. Yes, there is a complex ore problem in the sense you intend the inquiry, "complex ore" meaning a sulphide mixture. It would perhaps be better to say that there are complex-ore problems, because neither ore bodies nor treatments therefor are twice alike. This rather important fact, often overlooked, makes it difficult to say yes or no to all your questions without qualification.

2. By far the greater part of such ore can be successfully handled by mechanical methods, such as concentration, flotation and separation. "Successfully" in this instance means "profitably." Results are always better where skilled operators are employed. Failures may usually be traced to unskilled financing, engineering or operating. No one claims that mechanical methods are perfect or broadly economical, but they pay dividends. Some ores now in sight cannot be treated by mechanical means. Such ores must await new methods.

3. Not many mines containing complex ore are idle because of lack of suitable metallurgical processes. Idleness is due more to such conditions as inaccessibility, heavy snow, poor transportation, high freight rates, high fuel, distance from market, lack of water, poor financing, bad management, ignorance, and improper mining and milling methods. The complex-ore bodies of America, with two or three notable exceptions, are small, scattered and dissimilar, and this is the real complex-ore problem. It must be solved not generally, but each case individually.

4. I should say that fineness of crystallization, while not the sole cause of "complexity," probably causes the most trouble to mechanical processes.

5. Mechanical methods will hold their own for some time to come because results and costs can be safely and closely predicted from experiment and because small economical plants are possible for small ore bodies. Plant cost on most of the proposed chemical and electrical methods is prohibitive for small mines. Central custom plants like the present lead and copper smelters may eventually be established, but this will still leave the low-grade, inaccessible mine without an outlet.

6. The microscope always has helped the metallurgist and always will. The difficulty here is again the danger of generalization. Each ore will have to be separately studied and its proper mechanical treatment worked out. It is no uncommon experience to find today's mill supply from the second level a very different ore and problem from yesterday's tonnage from the fourth level. It by no means follows, either, that mixing the two for an average feed gives the best results.

My general conclusions are that the problem is not one of processes so much as one of economics of mining—the location, size and character of the ore bodies. Show the metallurgist the ore and he will successfully treat it, *if there is enough of it.*

Denver, Colo.

**Robert N. Bell:**—There is a "complex-ore problem." As to what constitutes a "complex" ore, I would say that I have a deposit in mind, where a considerable tonnage is available, in which the ore consists of zinc-lead-iron sulphide forming an amorphous blend, with absolutely no crystalline grain except scattered crystals of pyrite that contain equal proportions of lead-zinc-iron sulphides. There is hardly any gangue material. The ore breaks with a conchoidal fracture, and has a grain like broken steel. Some able metallurgical talent has tried to separate the more valuable minerals in this ore, but without results worth speaking of. Of course, it could be smelted, but the zinc would be wasted and the lead would not carry the cost of shipment and treatment. A similar condition prevails in less degree in a fine-grained crystalline ore from the Morning mine, at Mullan, Idaho, where successful advances have been made in separation through improved flotation methods.

As an example of refractory ore I would cite one which is a solid mass of arsenical pyrite, almost grainless in texture. It constitutes about 60 per cent of the ore-body, and contains about 6 per cent lead, 12 per cent zinc and 6 oz. silver per ton, the latter associated with the lead. This ore has resisted all attempts at separation by leading metallurgists, but is now undergoing further experimentation.

In my opinion, hydrometallurgical and chemical means will have to be employed for the successful treatment of such ores.

Microscopical examination has been of material assistance in the advances made in treating ores from the Coeur d'Alene (Idaho) district.

Boise, Idaho.

George E. Collins:—I. I suppose a "complex ore" is any ore which contains several valuable metals which have to be separated, or partly separated, in order to obtain marketable products. Accepting such a definition, there would be as many "complex-ore problems" as there are complex ores. Popularly speaking, complex ores are mixtures of zinc sulphides with lead, iron or copper sulphides.

2. Such ores are amenable to (imperfect) separation by known methods, or combinations of methods, but usually with partial success, because of the losses incidental to separating and marketing. In other words, but a small portion of the gross value of the metals contained is received by the original producer of the ore. The other methods proposed, such as electric smelting, chlorination and various forms of leaching, have not been sufficiently tried out under actual working conditions to justify positive conclusions as to their scope, or to enable the metallurgist to figure on the commercial results to be realized from them. They are as yet possibilities (or probabilities), rather than practical processes.

3. There are great numbers of mines now idle which could produce a large aggregate tonnage of complex ores, if it were commercially remunerative to apply known methods, or combinations of methods, or if other methods were available which could be successfully applied in small and inexpensive units.

The greatest difficulty is the small size of the orebodies in the vast majority of mines; which will warrant neither venturing experimentally into new metallurgical fields, nor even the installation of known processes, calling for expensive equipment. The majority of mines are small, and their life uncertain. Mines which will produce large tonnages are rare, equally when the ores are complex, as when they are simple.

So far as I know, there are few deposits now unworked of sufficient magnitude to justify experimenting with such processes as electric smelting or chlorination; which, even if eventually successful, are likely to be expensive luxuries for the pioneer. The details of such processes should be worked out by large existing producers, or by associates of such producers. Perhaps this might even be a proper field for the activity of the United States Bureau of Mines, in view of the possible value of these methods in aiding the conservation of the mineral resources of the nation.

4. I do not know of any "element or quality" of complex ores as above defined which "makes them refractory to present processes," excepting, perhaps, the tendency for the constituent minerals to be closely interlocked with each other, and in some cases with gangue of similar specific gravity. It is mainly a matter of costs and market values.

5. At present, I think we are dependent on mechanical ore-dressing methods, with flotation as an alternative; in either case supplemented by magnetic or electric separation.

Eventually, I believe that electric smelting, along the lines suggested by Johnson, will be feasible, and perhaps also chlorination and leaching. The two former I think will usually be applied to ores on which a rough preliminary dressing has been made by flotation or concentration, for I cannot conceive of the costs being low enough to warrant omitting preliminary treatment. For the moment, not having been sufficiently tried out to afford definite data as to field for successful application and costs, they are outside the sphere of the engineer, but may enter it before long, especially in districts where cheap power is available.

6. Microscopic examination, with low power, is of great value in mechanical concentration, and also in electrostatic work. In both these lines it may be regarded almost as a standard practice. I do not know in what way it can be of value in solvent or fusion metallurgical methods.

Denver, Colo.

G. H. Clevenger:—There are, in non-ferrous metallurgy, a number of "complex-ore" problems, and inseparably associated with them, and towering above them, and of even greater importance, there is a low-grade problem. The metals can be recovered from all ores by known processes; but it is not always possible to do so at a profit. The demand for the metals and the exhaustion of many of the higher grade deposits, together with the economic necessity of producing them at a profit is responsible for the "complex" and the low-grade ore problem. There is also the ever-present possibility of recovering the metals at a still greater profit from ores now being profitably treated. Call this problem what you will, so long as the percentage of extraction is below 100 and the working costs are greater than 0 the metallurgist has it staring him in the face.

The term "complex ore" is used in so many ways that it is difficult to give a single definition which will hold in all cases. It at once conveys to the metallurgical mind an intimation of difficulties to be met and overcome. In the most general sense a "complex ore" would be one the constituents of which, and their occurrence, were such that the metals could not be readily recovered from it by ordinary methods of treatment. The extreme case would be one in which the ore cannot be treated by any known process at a profit. An ore ceases to be "complex" when difficulties connected with its treatment are satisfactorily overcome. For some time metallurgists have associated the "complex" ore problem more particularly with ores containing zinc associated with other metals.

All ores are amenable to present day smelting processes as applied for the recovery of the more common metals, copper, lead, gold and silver. This comes about not only through the flexibility of the smelting operation, but also through the present-day practice of locating large smelting establishments at railway centers, which makes possible the blending and mixing of a variety of ores. Thus, if one ore contains a high percentage of some objectionable element it is diluted by smelting with other ores. The large smelting interests located at central points, where they can draw ores from a number of districts, therefore known nothing of the so-called complex ore problem as regards these metals. True it is that they have their troubles, and that some ores are more easily treated than others, but notwithstanding this all ores containing copper, lead, gold and silver in payable quantities can be satisfactorily treated.

Zinc is troublesome in the smelting operation for the other metals, but as has been mentioned, even this difficulty is readily overcome by smelting very zincky ores with ores which are low in zinc, so the total mixture does not contain zinc in excess of that which can be economically handled in the smelting operation. While it is true that zinc does not prevent these other metals from being recovered, at the same time, with present-day smelting methods all such zinc, with the exception of the small amount recovered by the bag house, as in the Lewis and Bartlett process, is lost in the slag and the fume. Herein lies one of the greatest weaknesses of our present day smelting practice, in that there is a distinct economic waste going on as regards zinc, much of which will never be recovered. It must be conceded that sooner or later we must look to these sources for a large portion of our zinc supply. Therefore, this problem is of constantly growing interest, and judging from the amount of effort which has been expended upon it in the past few years, and is now being expended upon it, a satisfactory solution is not far distant. Therefore, as regards complex copper, lead, gold and silver ores, which are commonly known as smelting ores, the great problem is the recovery of zinc, and to a less extent other by-products.

In this connection I have in mind a California mine which for a number of years operated profitably, recovering copper and the precious metals by the ordinary copper smelting process. The zinc contained in this ore, which was entirely lost in the smelting operation, calculated at the ordinary market price for zinc, had a greater value than the other metals combined. If there were a satisfactory process for recovering zinc in conjunction with the other metals, this mine could greatly augment its present profit.

Much has been accomplished in solving this problem by separating a marketable zinc product by various concentration methods. Hydrometallurgical processes for the recovery of zinc have been beset with many difficulties and although an enormous amount of money has been expended in their exploitation, there is at present no plant in regular commercial operation which employs a process of this type. Electrothermic processes have received their share of attention, but opinion differs regarding their commercial applicability. Here the problem seems to be in the condensation of the zinc vapor.

When an ore contains too small a proportion of the valuable metals to render its shipment to a smelting plant for treatment profitable, the next possibility becomes local treatment. This may take the form of concentration, which produces a product of high enough grade to ship; and thus a profit is derived from an ore which otherwise could not be treated. In the past this has been the only alternative with low-grade copper and lead ores, but at present there are a number of hydrometallurgical processes for low-grade copper ores which are being rapidly developed.

For years the ordinary process of plate amalgamation for the recovery of gold has been practiced in the most remote of mining camps. It is perhaps the simplest and cheapest of metallurgical processes but it is suited only for the recovery of gold occurring in the native state. While little more could be desired of a process in point of simplicity, yet as ores have changed in character through the discovery of new occurrences, and the attainment of greater depth upon the old deposits, simple ores became "complex" ores as regards plate amalgamation.

These ores therefore presented the low-grade ore problem as regards smelting, and the complex-ore problem as regards the simple process of amalgamation. The cyanide process practiced either singly or in combination with other operations as amalgamation, concentration, roasting, etc., has done much to solve the low-grade ore problem of smelting and the complex-ore problem of amalgamation, as regards gold and silver ores. But complex-ore problems have arisen in the operation of the cyanide process; for example, suppose we have an ore containing some copper, in which gold and silver predominate, which cannot be profitably smelted. If there is a sufficiently high percentage of copper in the soluble form, such an ore cannot be cyanided on account of the copper, which not only interferes with gold and silver extraction, but also causes a prohibitive cyanide consumption. The inability to treat gold and silver ores containing copper is today one of the weak points of the cyanide process, and may be said to be one of its "complex-ore" problems. Another "complex-ore" problem of the cyanide process is a most perplexing difficulty which arises in connection with the application of the cyanide process to the treatment of certain silver ores. This problem is not, as many have supposed, associated with the treatment of the unoxidized or lower-level sulphide ores, but is a result of oxidation either through natural causes during or after ore deposition, or of oxidation artificially induced as in the oxidizing roast. This difficulty frequently arises in treating ores containing the oxides of manganese and the manganese has therefore frequently been held to be the culprit; but there are reasons for believing that the silver is not in combination with the manganese in such cases.

The lack of a skilled operator will cause the failure of any process; but as there is no lack of skilled operators for all metallurgical processes, the owner has no one but himself to blame if his metallurgical ship goes aground on this shoal.

The mining engineer is best qualified to answer the question regarding the amount of complex or low-grade ore which mines now idle could produce. Judging from what I myself have observed and from what mining engineers of extensive experience have told me, the amount of such ores awaiting a satisfactory process of treatment has been greatly exaggerated. It is no unusual thing for tremendous deposits of two and three-dollar ore to shrink into nothing upon careful examination. Therefore the legitimate complex and low-grade ore deposit must be carefully sorted out from the many supposedly valuable deposits awaiting satisfactory methods of treatment. The first step in an investigation of this kind is to retain a competent mining engineer. Frequently he will be able to complete the investigation without the aid of the metallurgist.

Although the mechanical side of metallurgy has reached a very high stage of development, unquestionably far in advance of the chemical side, one would scarcely venture the opinion that there was nothing further to be accomplished in this line; but it does seem probable that the most important developments of the future will be made upon the chemical side of the subject.

There have been a great variety of electrometallurgical processes tried on a commercial scale in the Western mining states; but the performance in most cases has been disappointing. Notwithstanding previous failures there are many of us who still hope for important developments in this direction, but it is impossible to predict along just what lines.

Hydrometallurgical processes are of rapidly increasing importance and in the course of time they will take first rank for the recovery of certain of the other non-ferrous metals, as they have done with gold and silver through the cyanide process. This seems to be particularly true of copper. The incentive for this development is due, on the one hand, to the high losses of metal occurring with present-day concentration systems, as applied to the treatment of the low-grade ores; and on the other, to the increasing difficulties with the smelter-smoke problem. It is my belief that one great solution of the smelter-smoke problem, as well as of overcoming the trying losses which occur in the concentration of low-grade copper ores, will be the operation of a hydrometallurgical process or processes, which will recover directly a high percentage of the copper without disturbing sulphur, arsenic, etc. When this happy day arrives, we will take out the valuable constituents of the ore without in any way altering the objectionable gangue minerals. After all, the best solution of the vexatious smelter-smoke problem is not to make the smoke. Are we hoping for too much, to expect that in the future a solvent will be found for copper in its common combinations, which will remove the copper from most ores regardless of whether the gangue is largely silicious or basic, and without disturbing the major portion of the sulphur and arsenic? I think not. Consider what is now an accomplished fact through the cyanide process with gold and silver ores. It is now possible in most cases to treat concentrates containing gold and silver, consisting largely of the sulphide minerals, more economically than they can be smelted and without disturbing the sulphur. The sulphur goes onto the dump in the form that it came out of the ground, minus the gold and silver. Every day we hear of a new application of this process, even to very complex ores which it was formerly thought were either too complex or too high-grade to treat by such methods, therefore must be smelted. Perhaps the most convincing argument in this line would be to refer to what has been accomplished in treating the high-grade ores of the Cobalt district, where ores which carry approximately 39 per cent of arsenic, together with many other impurities, and on an average about 10 per cent of silver, are today more economically treated by a hydrometallurgical process than by smelting, and without contaminating the atmosphere with arsenic. I do not wish to be understood as predicting that the smelting of copper ores will be entirely supplanted by hydrometallurgical methods, for there doubtless always will be cases where hydrometallurgical methods cannot be applied to the best advantage; but the extensive development of hydrometallurgical methods is going to prove a solution of some of our present-day ore-treatment problems.

Microscopical examination will eventually have its place in the working out of the problems of ore treatment, but just at present there is a serious difficulty in its application on account of the fact that the specific effect of the various minerals has never been thoroughly worked out for the different processes. However, it must be remembered that at best microscopical examination would only assist in locating the difficulty, and that the major portion of the problem lies in finding and applying the remedy.

Palo Alto, Calif.

**H. A. Guess**:—1. There always is a complex ore problem, but of late no doubt more prominence is given to it as the simpler ores get scarcer. A complex ore from the ore-dressing viewpoint is one difficult to separate into marketable products, either because the minerals of the different valuable metals are too intimately and finely mixed, or are of about the same specific gravity, or have a gangue or a portion of it, of about the same specific gravity as the minerals.

2. It is doubtful if the present processes, even the newer ones, will satisfactorily treat the more difficult of these complex ores.

3. There are, no doubt, some mines now idle which could produce a considerable tonnage of such ores if suitable methods of treatment were available.

4. The cause of refractoriness has been touched upon in 1.

5. Each of the three types of processes you list will doubtless contribute toward successful treatment of difficult ores.

6. Where the minerals are very finely and intimately mixed, microscopic examination of the fine screen sizes, say of tailings, often aids in showing how fine it is necessary to crush to effect complete liberation of the minerals.

New York City.

**F. W. Traphagen**:—1. There certainly is a "complex-ore problem." Complex ores are: First, ores containing several metals in such intimate mixture that direct smelting or ore-dressing methods are inapplicable, and in which no one or more metals can be sacrificed commercially for the recovery of the others. Second, ores in which the losses by dressing methods are so great, because of the production of rich slime, or tailing, or mixed concentrate, that ordinary methods of treatment would yield little or no profit. Third, ores from mines so situated geographically that the ore or concentrate therefrom would yield no profit because of high freight and treatment rates.

2. Undoubtedly improvement could be made in present practice by skilled operators, but there is not as much room for progress in present methods, particularly mechanical processes, as in the development of new methods.

3. There are undoubtedly many properties that would yield large tonnages of ore that cannot be handled under existing conditions, if suitable methods of treatment were developed.

4. No particular element is responsible for the refractory nature of complex ores. Zinc is objectionable in lead and copper smelting for several reasons, and, in addition, is completely lost in those operations. Lead is not saved in modern copper smelting practice. The difficulty in treating complex ores lies in the fact that our metallurgical processes save but a few metals and sacrifice others of value. This is the principal phase of the "complex-ore problem."

5. The solution of the problem lies in the development of some method involving a combination of hydro- and electrometallurgical practice. The process should be applicable at or near the mines, and produce metals of products of sufficient purity to be marketed at once, without the necessity of sustaining additional charges to make them sufficiently high grade to market.

6. The microscope is of great value, especially as indicating whether dressing methods may prove valuable. I had one sample of complex-ore in which the minus 200-mesh grade showed under the microscope an intimate mixture of blende and galena. Such a mixture could not be separated by concentration.

Golden, Colo.

**L. S. Austin**.—In addition to defining "complex ores" as mixtures of base-metal sulphides, I might further limit the definition to cover mixtures, in the treatment of which the extraction of one metal interferes with the recovery of another. Thus, a lead or copper ore containing gold and silver only, while complex, presents no difficulty in the extraction and separation of its constituent metals. Again, an ore that is a combination of chalcopyrite, pyrite and galena, with gold and silver, should, after roasting, be quite suited to blast-furnace treatment. But the complex ore regarding which the question of treatment has been in dispute, appears to be one containing zinc as blende, in addition to the sulphides noted above.

Practically, either in copper or lead smelting, zinc is a detriment and so is penalized. After roasting, such an ore can be treated in the blast furnace, but the zinc is never recovered. It principally enters the slag; in part it goes into the matte, and in part is volatilized, forming accretions in the shaft of the furnace. In consequence of its volatile nature it takes away silver that should have gone into base bullion or matte. In silver-lead smelting, with a charge high in zinc, one has to modify the type of slag, making it more irony and less silicious than if it were zinc-free; and so, where fluxing iron cost money, zinc stands for a higher smelting expense per ton of materials of the charge. To keep such a slag fluid requires a little more fuel. In smelting copper ores the same drawback occurs, though in less degree, since the zinc is more easily volatilized. That the presence of zinc constitutes a real detriment is shown, in that in Colorado it is penalized when the ore contains over 10 per cent., at the rate of 50 cents per unit (1 per cent). In Utah zinc is free up to 10 per cent, and sometimes to 17 per cent; above that limit a penalty of 30 cents per unit is incurred.

To aid in the solution of the difficulty in the reduction of zinc-bearing lead sulphides, the United States Smelting, Refining & Mining Co. have in operation at their Midvale plant a concentrating mill where they separate the lead, and from the concentrates made in the wet way, the zinc by the Huff electrostatic machine. For ores suitable to this method of concentration they will then pay as follows:

For metals, the gold at $18.00 per oz.; 80 per cent of the silver at the New York market price; 80 per cent of the lead at that market price per pound less $1\frac{1}{2}$c. Ten per cent of silica is charged for at 12c per unit or $1.20 in all; 60 per cent of the iron is paid for at 6c per unit, and 30 per cent of the zinc at 2c per pound.

In silver-lead smelting, copper, when present in the ore, goes into the matte, and is in consequence recovered. In copper smelting, on the other hand, if lead is present it is volatilized and no attempt is made to recover it—it is a complete loss. Provided it is primarily a copper-bearing ore, this loss need not be a serious one, and it is better to lose two or three per cent of lead rather than to adopt some special process to recover it, or attempt to send it to some silver-lead works to obtain such recovery.

In the year 1903 the American Smelting & Refining Company smelted ores of a gross metal value of $33 per ton. At the end of. 1911 they were treating ores of an average gross metal value of but $16 per ton, some of course high in zinc. When we consider that from this value of $16 is to be taken the cost of mining, freight and treatment there seems but little margin to compensate the mine owner.

Mr. Johnson, of the Continuous Zinc Furnace Co., has lately been bringing to our attention his electric process for the recovery of all the metals in a complex ore, containing not only the base metals, zinc, lead and copper, but the contained silver and gold as well. He has done this with a great degree of success, but at a cost of $10 to $12 per ton. Now it is obvious that the complex ores awaiting new methods of treatment "of which millions of tons exist" would not stand such expense for treatment, and it would probably be found that their contained metals would not aggregate in value a figure that would bring them in the category of ore, if such a mineral were to be defined as one commercially profitable.

As an evidence of the complexity of many ores treated at custom silver-lead works, let us consider the constitution of the copper-lead matte produced by them. This matte when produced is roasted, sintered and again returned to the furnace. Each time it goes through the furnace it picks up impurities from the charge. Finally, when its copper content has reached a proper figure, it is withdrawn from the circulation, separately smelted to yield a matte of 40 per cent or more copper, and sent to a refinery for converting, yielding blister copper and bag-house fume.

An average analysis of the matte is as follows: Pb, 26.9 per cent; Cu, 43.1 per cent; Ni and Co, 0.4 per cent; $SiO_2$, 0.3 per cent; Fe, 8.0 per cent; Zn, 2.5 per cent; S, 15.5 per cent; As, 1.7 per cent; Sb, 0.76 per cent; together with Au, 0.17 oz. and Ag, 98.1 oz. per ton.

The fume yielded in converting is found to contain: Pb, 52.5 per cent; Cu, trace; Zn, 3.0 per cent; S, 5.4 per cent; As, 14.2 per cent; Sb, 1.6 per cent; Te, trace; and Ag, 10.0 oz. per ton.

Thus, besides the metals we expect to find, there is present in the matte nickel and cobalt as well as arsenic and antimony; in the fume are both of the latter metals, a trace of tellurium and much arsenic. All these metals are detrimental, and when in sufficiently pronounced quantities are penalized. Another metal, more volatile than zinc, and entering the bag-house fume of the blast-furnaces, sometimes to the extent of from 15 per cent to 20 per cent, is cadmium, not to mention arsenic. Since the flue-dust goes back to the blast-furnaces for the recovery of lead, these metals continually climb to higher percentages in the closed circuit until, like an electrolyte, they must be removed for special purification.

There is no question to my mind, that with the advance of metallurgical methods, the day will come when many of these low-grade ores will be commercialy exploited, but the day is not yet. In looking for the best methods of treatment no doubt microscopic as well as chemical methods of analysis will be of much aid. In what directions reduction methods will develop it would be hazardous to suggest, but as I believe, not in the line of pyrometallurgy.

Salt Lake City, Utah.

**Edward S. Wiard.**—There is a complex-ore problem. I would define a complex ore as a mixture of two or more base-metal sulphides in gangue, at least two of which are of commercial value.

Present results from the treatment of such ores would be improved by skilled operators. There are no new methods in use at present, but it might confidently be expected that improved processes would arise from a more refined employment of present methods.

The number of available mines with complex ores, now idle, from which refined methods of ore treatment would win a profit is small, but they do exist.

A difficulty encountered in treating these ores is that the commercial sulphides have too nearly the same specific gravity. As the minerals become more finely disseminated they become more refractory. Refractoriness in such ores may be said to be represented by the product of the first factor times the square of the second.

In my opinion, mechanical processes will be more generally applied in the treatment of these ores.

The use of the microscope in connection with complex ores will be of value only as it gives better vision than can be had with the naked eye.

Denver, Colo.

**R. C. Canby.**—1. Literally speaking there is undoubtedly a "complex-ore problem" as applied to ores such as those to which your terms have reference; that is, the base-metal sulphides, especially where these sulphides are so finely disseminated as to require particularly fine grinding to separate the different sulphides from one another. More broadly speaking, however, the entire field presents problems, the gradual mastering of which is bringing under profitable treatment ores which were previously of no commercial value. Such a base-metal sulphide would be "complex" when containing zinc, especially in combination with copper, particularly when the sulphides are finely disseminated.

2. Strictly speaking the amenability of these ores to present processes is not a question of operating skill.

3. Many mines are now operating at an economic disadvantage, and there are also many deposits which will eventually develop into mines as metallurgical progress is made.

4. In the ores referred to, it is unquestionably the sulphide of zinc which renders them "refractory." It is not altogether, however, owing to the difficulties arising from the presence of the zinc which calls for a more suitable method, but because in the usual treatment of such complex ores, at present, the zinc content not only incurs treatment penalty but is also lost, either in the concentration or in the smelting.

5. Of the new or unusual methods, "flotation" is already producing enormous quantities of zinc heretofore lost, and is making possible sulphide savings which were previously impossible. Flotation, like other forms of mechanical concentration, however, is only a partial or preparatory step. Gradual improvements in the methods of smelting these concentrates will be made to suit the various products and local conditions. I am inclined to believe that electrometallurgical treatment will be brought about eventually through the development of hydroelectric power, making cheaper power available.

6. Microscopic examination of finely disseminated sulphides reveals much of interest, not only as to the minerals present, but as to the mineralogical history of the ore. It seems that the microscope is, however, more interesting to the mineralogist than to the metallurgist. Minerals so finely disseminated as to become microscopic evince their close dissemination by a more cursory examination than that of the microscope.

Miami, Ariz.

E. L. Godbe.—1. Unquestionably there is a "complex-ore problem." In the generally accepted sense, a complex ore is one containing a very fine and intimate mixture of base-metal sulphides, principally, zinc, lead and iron, the separation of which is difficult or impossible by gravity methods of concentration. Many other ores are complex in their nature, by reason of the fact that well known metallurgical methods will not work them to advantage, yet these are not generally regarded as coming under the caption "complex ores."

2. In the very large majority of cases, the so called complex ores, I think, are amenable to present processes, and the only thing necessary to apply them profitably is metallurgical skill in working out the various details, the shaping of economic conditions, and in the acquisition of sufficient capital to construct proper plants. The average mine operator is very skeptical in regard to the adoption of new methods, owing to the fact that so much money has been lost in untried and impractical processes in the hands of unskilled metallurgists. On the other hand, there are certain ores the minerals of which are so intimately associated as to be almost chemically combined, and for this kind of ore there seems to be little doubt but what new methods will have to be devised.

3. There are a great many mines scattered throughout the West which can produce a very large tonnage of complex ores, and very profitable results will follow the adoption of suitable methods of treatment. In order to work out and solve these problems the most essential thing, in my opinion, is careful experimentation in the hands of competent metallurgists. The great difficulty experienced so far in the working out of these problems is the inability to find properly equipped laboratories where all the known methods of treatment can be tried on any particular ore. As every one has its own peculiar characteristics, no operator can tell how any process will work, except by trying it, and it is safe to say there is not a single laboratory in the United States where all of the various known methods of treating complex ores can be definitely tried out. If the miner could take his ore to, say a first-class government laboratory, one that is thoroughly equipped with facilities for testing out all of the modern improved methods, such as flotation, roasting, wet and dry separation, gravity concentration, to say nothing of the still newer methods such as volatilization of sulphur, reduction of the metals to the metallic state with subsequent concentration, volatilization of zinc and lead and condensation in the metallic as well as the oxide form, etc., there is little question but what a satisfactory solution of almost any complex-ore problem could be found. Furthermore, the report of such a laboratory would enable a mine owner to acquire sufficient capital to build proper reduction works. After having been once installed, a laboratory of this character should be self supporting.

5. For the real complex ores, without doubt, the mine owner will have to look to the hydrometallurgical and electrometallurgical methods for relief. Great progress is constantly being made in the development of these processes, and while to-day it cannot be said that any one of them is an established success, yet they certainly do give bright promise for the future. There are so many methods suggested along these lines, the application of which will doubtless be confined to certain particular kinds of ore, that it would be difficult to say just which ones present the greatest promise. As electricity is rapidly becoming an important factor in almost every hydro-metallurgical process, it is safe to assume that its use will largely increase.

6. Microscopical examination would undoubtedly greatly facilitate the diagnosis of any particular ore, but in itself I do not think it will play a very important part. In my opinion, what is most needed to solve this complex-ore problem is properly equipped laboratories, competent operators, plenty of money for experimentation, intelligent working out of economic conditions, and, last but not least, more faith on the part of mine managers and owners.

Salt Lake City, Utah.

---

**A Manual of Electrical Testing** is the subject of a new forty-eight page bulletin, size 8 x 10½ in., issued by the Wagner Electric Mfg. Company of St. Louis. Besides describing the line of portable instruments manufactured by the Wagner company, this publication describes various types of electrical instrument movements, the errors to which they are subject and gives suggestions for their handling and care. The methods of making electrical test on alternating-current and on direct-current motors and generators and on transformers are described at length and illustrated by comprehensive and instructive diagrams.

# The Metallurgical Engineer in the Steel Works

BY JOHN HOWE HALL

In their attitude toward the employment of metallurgical engineers, managers of shops may be roughly divided into three classes: those who utterly disbelieve in metallurgists, those who employ one for show purposes, but pay no attention to his recommendations, and those who believe that his efforts, properly directed, are of value.

Managers of the first class say "Look at so-and-so, who worked up from the bottom and ran the great shops at such-a-pace! You didn't catch him bothering his head with fellows with 'highfalutin' notions. Practical man, he was, and employed only practical men!" Of course, there are at least two points in the case of their hero that they overlook. First, he made his way to the top in pioneer days, when the margin of profit was large and expert knowledge limited; second, in his later career, it is a hundred to one that the great magnate made use of the services and advice of experts in various lines, in order that his shop might continue to make money in times of increasing competition and decreasing margins of profits, and to keep abreast of its competitors in the quality of its output.

In dealing with managers of this class one hears the words "Practical Man" about every third sentence. The definition of a practical man seems to vary more widely than any known variable in a steel works. Reduced to its lowest terms and defined by negative methods, it appears that to a great many managers any one who submits for consideration a proposal based upon a reasoning process which the manager does not understand, is *not* a practical man, and should be treated accordingly.

The second class, fortunately rare, is composed of those who do not believe in metallurgists, but who see successful shops employing them, and in order to gain a reputation for progressiveness, engage an unfortunate individual to play by himself in a corner and be exhibited with a flourish to visitors—"Our research laboratory, you know, where our new processes are worked out." The vistor is much impressed. Managers of this class take such elaborate precautions to keep the metallurgist from all contact with the actual routine of the shop, as to give the impression that they would be pained and grieved if the unfortunate man actually succeeded in surmounting the barriers raised around him and contributing something of value to his employers.

Coming now to those who believe that the metallurgist can be made of value to his employers, we find wide differences of opinion as to how he should be made use of. To take the widest extremes, let us consider the manager who believes that his metallurgist is of value only to conduct "post-mortems" upon material that has failed in service, and the manager who believes in obviating the necessity of post-mortems. It is often said that the methods of the metallurgist are of value only as a post-mortem. Stripped of the specious pleas that always accompany the statement, this means that the knowledge that is capable of explaining the failure of a piece of work, could not have foreseen that failure if applied to the object before it was shipped. We see at once that if this is true, then it must be a fact that all causes of failure are so hidden in the objects manufactured that they can not be detected without destroying the objects. It requires but a slight stretch of imagination to see how false is this assumption.

The causes of failure in service will be of two classes, those that could have been discovered by examination of the material before shipment, and those that could not. In addition, of course, there will always be the "mysterious" failure to which we shall refer again a little later. Granting that the metallurgist should only conduct post-mortems, ascertain the causes of failure, and point them out to his employers, on whom is to fall the burden of making sure that the product thereafter is free from the defects that have been found to cause failure? For unless failures are to be lessened, surely the post-mortem itself is a waste of time and money. There is no profit, and but poor consolation, in knowing why a piece of work failed, unless we hope to prevent the failure of other pieces from the same cause.

Many of the causes of failure disclosed by post-mortems are of a nature that only the expert can apprehend. How shall the practical men in the shop be able to recognize them in the future, and guard against their recurrence? Again, if the cause of failure be plain to the ordinary shopman, how far can we rely on his intelligence to understand the necessity of condemning the material suspected? His job is to produce the maximum tonnage of material fit to ship; the more material is condemned, the less his output. Hence his whole mental attitude is such that he is sure to throw the weight of his influence toward shipping everything that passes a casual inspection, and taking chances on the issue. Both by training and by inclination, he is the man of all men about the shop who is least likely to be active in condemning poor material.

It is evident, then, that the man who conducts the post-mortems should be in a position to recognize defective material before it is shipped—if possible before it is finished. To ensure this, all processes in the shop in which inferior work may be done, *must* (not may) be subject to his check.

Moreover, there is another side to the question. In conducting a post-mortem, a man who does not have at his disposal a mass of data on the properties of the materials the shop manufactures, is forced to rely solely upon a general knowledge of the subject, based upon the work of independent investigators, which is all too scanty, and in but few cases applies directly to the problem in hand. It is then almost impossible for him to ascertain the true cause of the failure. Here we see one of the serious disadvantages of relying upon examinations of failed material, made by an expert who may be a thousand miles away, and familiar only in a general way with the materials the shop produces. His opinion is necessarily couched in rather general terms, often covering several possible causes of failure, because in most cases he cannot be really sure of the exact one. He fires a shotgun into the flock, as it were, instead of picking out with a rifle the particular bird that is doing the damage.

In order to form an opinion of value from a post-mortem, therefore, the metallurgist must have data as to the nature of the material which the shop has been producing, and as to its behavior in service; and in order to apply the conclusions obtained from a post-mortem to the material being made, that material must be constantly subject to the metallurgist's check. Thus either way we look at the matter, we see that the three functions of the metallurgist are inseparable one from the others. He must conduct post-mortems on failures, check the material being manufactured, and apply the knowledge gained from both sources to the improvement of the product. The material that can be recognized as liable to failure from a cause identified by post-mortems, can then be held up, and its failure prevented; and by tracing to their origins both this class of defects and those that cannot be recognized by an examination of the material before shipment, the failures of both classes can be minimized.

The "mysterious failures" will at first be numerous. It will be found, however, that by keeping a full record of them, and by having them constantly in mind, they will soon be recognized as falling into several classes. As data from the examination of material before shipment accumulates, light will be thrown on the causes of more than one class of unexplained failure, and the number of kinds of mystery will be greatly reduced. It may safely be said that the greater number of unexplained failures are "unexplained" solely from lack of systematically collected data upon which inferences may be based.

It is plain that if the metallurgist's services are utilized in this manner, he will work in collaboration with the manufacturing department, the claim agent and the engineering and sales departments. The routine of the activities under his control should be so arranged that the manufacturing department must submit daily to his inspection tests taken from the product itself or from coupons, that shall cover the operations of the day to a sufficient extent to guard against the possibility of the shipment of a lot of defective material. The defective material brought to the notice of the claim agent must be examined, and the cause of failure ascertained and traced to the operation responsible for the trouble. The daily testing of current product and the examination of material that has failed in service, will suggest many improvements in both processes and product. The metallurgist will co-operate with the manufacturing department in making these improvements, and with the engineering and sales departments in the marketing and utilization of improved material.

Some managers install apparatus for microscopic examination and physical testing of their material, and put it in charge of a young man without technical training. He is the information-gatherer, and his reports are forwarded to someone higher up, generally the superintendent of the shop. The latter is often too busy to use the information to the best advantage, and in many cases lacks the technical education and training requisite to a proper understanding of the problems brought up.

Again, a young man from college, with a good technical education but no experience, is given charge of the metallurgical work. Until he has acquired the necessary practical experience, the conclusions he may draw from his work are of but little actual value, for he is sure to "go off at half cock" every little while; and in a laboratory, practical experience is absorbed slowly.

The best advice to give a technical college graduate who wishes to be a metallurgist is to put on overalls and work two or three years in the shops. For a while he will learn new facts so fast that he will feel almost contempt for the technical knowledge acquired in college, and will think "Yon Yohnson" knows more than Professor So-and-So. Then he will begin to see Yon's great limitations, as well as the undoubted value of his practical information, and with the two kinds of knowledge he has acquired, will gain an understanding of the inwardness of steel works operations that will be invaluable to him and to his employers.

Such a man in a large works can be employed constantly, overseeing the activities of a number of assistants, and with plenty to keep him more than busy. The small shop, on the other hand, cannot afford to pay a salary such as this man is capable of commanding. They must, therefore, employ a younger man, college graduate or home trained, to carry on the routine work, and engage an experienced metallurgist to map out the work in the first place, to consult with the management in interpreting the results and making the changes in shop practice that may be found necessary, and perhaps from time to time to extend the activities of the metallurgical department.

Such an organization can be as simple or as elaborate as the size of the shop and the diversity of its output necessitate. It may include only the daily or weekly testing of a few samples by the chemist in his spare time, or even by an outside firm who will take the work at a fair price on a yearly basis; and at the other extreme, it may include the employment of a large staff under the direction of a resident metallurgical engineer. To-day, with the great increase of our knowledge of iron and steel and the growing demand for superior products, it is a very small shop indeed that can afford to dispense with the systematic checking up of its output by technical men of knowledge and experience, along the lines here suggested.

New York City.

---

The Eastern Tanners Glue Co. of Gowanda, N. Y., which ranks as the largest glue factory in the world, has just put in a third Swenson evaporator for making glue. This is the largest of the three outfits in the plant. The Eastern Company is noted for its labor-saving devices, including automatic industrial cars which take a certain number of hides directly from the railroad spur, stop at any predetermined vat, dump the hides into it, and then return automatically to the place of loading, alongside the railroad car. Due to the extensive use of such devices all over the plant, this company has found it possible to make glue at so low a figure that some other manufacturers, in order to tide over a sudden demand beyond immediate capacities, are said frequently to purchase glue from the Eastern company at a figure not higher than their own costs.

**The attitude of the Canadian people** toward the development of radium in the Dominion is reflected by the action of the provincial governments of Ontario and British Columbia. In the former, a legislative bill provides for a reward of $25,000 to the first person who discovers radium in the province in sufficient quantity for commercial extraction. The bill also authorizes the government to reserve all radium in Crown lands, with the right to work deposits, and install necessary equipment and plant. The sale of radium is to be conserved and regulated by the government. In British Columbia the prize offered for discovery of radium is $5,000, and a reserve is placed on all public lands in which radium may be found. The bill provides for regulation of the radium industry, and for a retention by the Crown of a 50 per cent interest in all radium produced.

**The newly formed Chicago Section** of the American Institute of Mining Engineers held its first annual dinner and meeting at the Sherman House on the evening of April 14. The officers elected were: Chairman, Robert W. Hunt; vice-chairman, J. C. Ede; secretary-treasurer, H. W. Nichols; executive committee, F. K. Copeland and G. M. Davidson. The next meeting will be in May.

# Cascade Attachment for Graphite Furnace *

BY EDWIN F. NORTHRUP

If a cubical space, in which the atmosphere cannot circulate, contains graphite and is brought, by an input of electrical energy, to a temperature in the neighborhood of 1000 deg. C. or more, the atmosphere in this space becomes converted into an atmosphere which is chemically inactive in respect to graphite. If a graphite resistor, through which a separate source of current may be run, is centrally located within this space it may be brought, by an input of sufficient electrical energy, to a temperature little short of the vaporization point of graphite without any observable chemical reaction of the resistor with the atmosphere. The resistor is quite as inert as if located in a perfect vacuum. Furthermore, since experiments show the above statements to be true, the idea is at once suggested that, if the cubical space be made of steel walls capable of sustaining a pressure of many atmospheres, the vaporization temperature of graphite would be greatly raised and thus enable the artificial production of temperatures exceeding considerably the temperatures of the carbon arc.

As everything tends to evaporate more readily with diminution of pressure, it seems to the writer that the use of a vacuum furnace for obtaining the highest temperatures is a step in the wrong direction, and that it would be better to aim at obtaining a furnace in which the pressure might be made very great, and the atmosphere made absolutely inert by electrically heating comparatively large masses of graphite to a moderate temperature. One may then obtain the desired maximum temperature by a rapid input of a large amount of energy in a small and centrally located resistor unit.

These ideas have been tested by the writer at atmospheric pressure with complete verification. He hopes the opportunity may offer for carrying out similar experiments at enormous pressures.

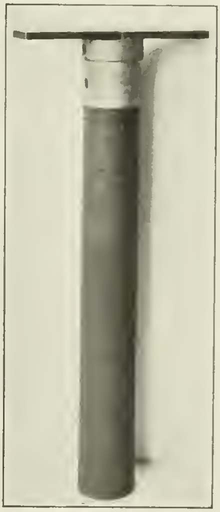


FIG. 1—CASCADE ATTACHMENT WITH ALL PARTS ASSEMBLED

The device, which this article describes, easily melts tungsten and gives a temperature, without perceptible depreciation of the graphite resistor unit used, which certainly exceeds 3000 deg. C. It is placed in and fills the chamber of the high-temperature graphite furnace described by the writer in the January, 1914, issue of this journal. The large furnace is first brought to a temperature of approximately 1600 deg. C. and then by means of a switch the energy (obtained from the same transformer) is transferred to the heating element of the device. This heating element is a slotted tube of re-graphitized Acheson graphite. The internal chamber, which acquires a perfect black body temperature exceeds 3000 deg. C. (or less if desired), is 15 cu.c. As the temperature is produced in steps falling from a maximum temperature in an inner chamber to a lower temperature in a furnace chamber (into which the device is readily fitted or removed), the writer has called it a "cascade" attachment.

The high temperature attained in the cascade attachment with energy obtained from a single transformer, is made possible, first, because the chamber of the large furnace develops an atmosphere which gives absolutely complete protection against chemical action with graphite and, second, because the energy yielded by the transformer is first accumulated and stored in the refractories of the furnace of large heat capacity, and then additional energy, before the furnace cools much, is concentrated in a relatively small heating chamber.

The cascade attachment consists of a graphite tube which fits the furnace chamber, of two massive graphite terminals or electrodes, two nickel-plated iron terminals, a furnace cover and head piece of refractory material and a replacable resistor-unit of Acheson re-graphitized graphite. There is also inserted through the bottom of the graphite tube a graphite plug which holds a replacable crucible of graphite (or any other material) and a graphite tube which surrounds the resistor-unit and shields the walls of the furnace chamber from the intense radiation which proceeds from the resistor-unit. Fig. 1 shows the cascade attachment with all parts assembled and ready to place in the chamber of the furnace and Fig. 2 the same with its parts unassembled.

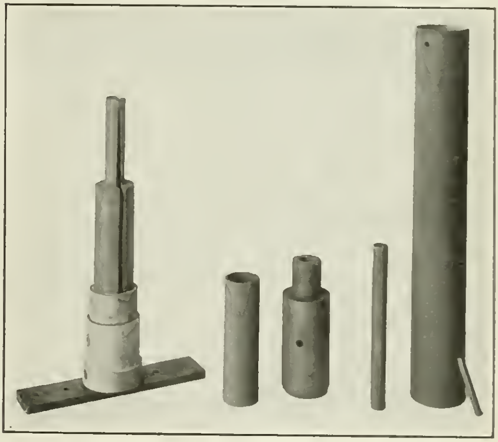


FIG. 2—PARTS OF CACADE ATTACHMENT UNASSEMBLED

The life of all the parts, except the resistor-unit, is indefinite. The resistor-unit is made to be readily replacable and is an extremely simple and inexpensive device. It consists of a tube of re-graphitized Acheson graphite, of which 7.6 cm of its length becomes heated. It is 1.55 cm internal diameter and 1.75 cm external diameter. This tube, which is slotted on two sides, slips into cuts in the massive graphite electrodes where it is held in position with two graphite screws. The crucible is a cylinder about 1.05 cm internal diameter and 7.6 cm deep. When in position it nearly fills the chamber of the resistor-unit.

To use the cascade attachment one proceeds as follows: The crucible is removed through the hole in the bottom of the cascade attachment and filled with the material which is to be submitted to the high temperature. The crucible, filled with its charge, is then replaced in the cascade attachment and held in its proper position by a graphite pin provided for the purpose. The cascade attachment is then lowered into

---

*The furnace referred to is the one described by E. F. Northrup under the title, "A New High Temperature Furnace," METALLURGICAL AND CHEMICAL ENGINEERING, January, 1914.

the furnace chamber. The heavy leads which are provided are fastened with thumb screws to the iron terminals of the cascade attachment. The other ends of these leads are attached to two poles of a double-pole, double-throw switch. The furnace terminals are attached to the remaining two poles and the transformer secondary terminals are attached to the middle point of this switch. The outfit is now ready to heat. The switch is thrown to "furnace," the voltage handle of the transformer is thrown to the stud giving highest voltage and the furnace is heated rapidly with an input of about 5 kw. While the transformer is nominally a 4-kw transformer, this output is for continuous operation and the transformer is not in the least strained when made to yield 5 kw for one or two hours nor by being made to yield 8 kw to 9 kw for five to ten minutes. When the current has been on the furnace for about seventy-five minutes, a temperature of about 1600 deg. C. being obtained, the switch handle is thrown to "cascade." The resistance of the heater-unit has been so chosen that the cascade attachment will take about 8 kw.

Several experiments with the cascade attachment were made by the writer. It required a number of trials to determine the proper dimensions and resistance of the cascade resistor unit for obtaining the highest temperature with the transformer employed.

A test was made April 1 to determine how long it would take and what energy would be required to bring to complete fusion a No. 20 tungsten wire. A piece of wire about 40 cm long was made perfectly straight. One end of this wire rested in the center of the bottom of the crucible and the other end projected through a hole about 1 cm in diameter in the top of the cascade attachment. The wire was centralized in this hole by means of a small plug of refractory with a hole in its center through which the wire would pass easily. At the instant a melt occurred the fact would be made evident by the wire sinking vertically downward into the crucible. The observations actually taken are directly transcribed in the table at the end of article from the writer's note book.

A curious and unexplained phenomenon was noted. Shortly after, but not immediately after, the switch was thrown to "cascade" the furnace developed a roaring noise. This noise increased in volume and became very loud before the wattmeter indicated any increase in power input. It was not due to an arcing, as no arcing occurred. In this test the wattmeter was placed on the primary side of the transformer and, on account of losses in the transformer and secondary leads, it is thought about 10 per cent should be deducted from the wattmeter readings when the switch was on "furnace" and about 15 per cent when the switch was on "cascade."

The following data are of interest: The average input (actual) on the furnace was 4.3 kw. The time of this input was fifty-three minutes. The total input on the furnace was, therefore, 3.8 kw-hours. As the outside of the furnace was still cold to the hand practically all of this energy was stored in the furnace. The average input on the cascade was 7.1 kw and the time of input on the cascade totaled 5.7 minutes. Therefore 0.675 kw-hours of additional energy was delivered to the cascade. The last time the switch was thrown on cascade the average input was 7.1 kw for 2.2 minutes, making 0.26 kw-hours input of energy which was required to bring about 15 cu. cm of space to the melting temperature of tungsten when the temperature of the furnace chamber was, by estimation, about 1600 deg. C. The outside area of the cascade resistor unit was 41 sq. cm. At the time tungsten melted 197 watts per square centimeter were being supplied to the cascade resistor unit. The volts at the cascade terminals were 28 and, by calculation from the input, the cascade resistor unit must have been taking 295 amp. The resistance of the cascade resistor unit, including its contact resistance with the graphite electrodes, measured 0.126 ohm at room temperature. Its calculated resistance when tungsten melted was 0.098 ohm, a decrease from cold to hot of about 22 per cent. The above figures must not be taken as very precise because the wattmeter registered the power input on the primary side of the transformer and because contact resistances may have amounted to several per cent of the total cascade resistance.

An examination next day of the resistor unit showed that it had suffered no deterioration. Its surface presented a satin-like appearance which showed, under the lens, that a slight vaporization from the graphite surface had started.

April 1, 1914. Observers—E. F. Northrup, Mrs. E. F. Northrup.
Test of cascade furnace after alterations.
Resistance of cascade attachment = 0.126 ohm.
Measuring current 10 amperes. Resistance decreases slightly with increase of measuring current.

| Time P.M. | K.W. on large furnace | K.W. on cascade | Notes |
|---|---|---|---|
| 2.00 | 4.6 | ... | |
| 2.05 | 4.5 | ... | Line voltage low. |
| 2.11 | 4.85 | ... | Line voltage raised. |
| 2.11½ | 5.00 | ... | Line voltage raised. |
| 2.15 | 4.78 | ... | |
| 2.26 | 4.7 | ... | |
| 2.28 | .... | 8.4 | On cascade for ten seconds. |
| 2.42 | 4.7 | ... | |
| 2.48 | 4.5 | ... | Line voltage lower. |
| 2.55 | .... | 8.7 | On cascade. |
| 2.56 | .... | 7.5 | |
| 2.57 | .... | 8. | |
| 2.57¼ | .... | 8.1 | |
| 2.57½ | .... | 8.2 | |
| 2.58 | .... | 8.7 | |
| 2.58¼ | .... | 9. | Tungsten did not melt. |
| 2.59 | 4.7 | ... | |
| 3.04 | 4.7 | ... | |
| 3.15 | .... | 8. | On cascade. |
| 3.16 | .... | 8. | |
| 3.17 | .... | 9. | |
| 3.17¼ | .... | 9.5 | Tungsten melted.<br>1 hour and 17 minutes from time furnace started heating.<br>Cascade attachment heated 2¼ minutes when tungsten melted.<br>Opened switch. |

A melt of the No. 20 tungsten wire was shown by the settling down of the wire which extended above the top of the furnace.

April 2. Examination of crucible showed that about 7 cm. of the wire had made a good melt, and the entire length at about the same instant.

Department of Physics,
Princeton University.

---

**Vismera Pure Iron** is the title of a booklet issued by the Inland Steel Co., of Chicago. Vismera pure iron is 99.86 per cent pure iron guarantee, has high tensile strength, perfect physical structure, and is rust resisting. The following analysis is said to represent regular practice: iron 99.882, no silicon, no copper, no aluminium oxide, 0.040 C, 0.004 P, 0.020 S, 0.040 Mn, 0.001 H, 0.009 g, 0.004 N. The total impurities are therefore 0.118 per cent. Vismera pure iron is made in black sheets, galvanized sheets, corrugated sheets, roofing sheets, sheared sheets, etc.

The **Mountain Copper Co.** will install two 8 ft. x 36-in. cylindrical herringbone gear driven Hardinge mills in their new concentrator at Keswick, Shasta County, California. The Miami Copper Company are at present installing additional Hardinge mills.

**Pyrometer Facts** is the title of an interesting little bulletin issued by The Stupakoff Laboratories of Pittsburgh, Pa., giving illustrated notes on the thermo-electric pyrometer, the wall-type galvanometer, the shelf-type and portable test galvanometer, the recording pyrometer, the "simplex" base-metal portable pyrometer, the platinum, platinum-rhodium thermocouple, the base-metal thermocouple, water jacket compensation.

**The Bethlehem Steel Company** is putting up a Cottrell plant to purify blast furnace gas.

# The Igneous Concentration of Metallic Values from Mixed Sulphides—II

## Utilizing the Fuel Value of Sulphides to Make a Sublimed Zinc Concentrate

BY F. L. CLERC

In a previous paper[1] on this general subject I have outlined the progress of the application of the pyritic idea to the metallurgy of copper, accepting the definition of a pyritic process to be one in which the heat generated by the rapid oxidation of metallic sulphides by an injected air blast is utilized to take the place of heat developed by carbonaceous fuels. The sulphides oxidized may be contained in ores as sorted at the mines, or in the mechanically dressed products of concentration, or in intermediate products of smelting operations. I have expressed the opinion that zinc smelters may profitably apply the same idea to the concentration of zinc in some ores low in zinc, forming a sublimed product rich in zinc, corresponding to the rich mattes produced by copper smelters.

This historical sketch, traced out by means of a selected class of events, namely, commercial tests on a working scale which have been carefully observed and recorded, is of interest to anyone who wishes to extend the application of the pyritic principle into other fields of metallurgy.

The main facts brought out may be reviewed. The first working test I have quoted was preceded by a long line of laboratory experiments which had determined chemical facts and measured physical constants with great precision. The results of this laboratory work take high rank as contributions to human welfare; they were essential to any industrial application. With these data at hand, small scale metallurgical laboratory experiments were tried, to solve one or more problems involved in industrial enterprises.

A striking feature in this development is the fact, clearly shown, that many years elapsed after a practical and public demonstration of the merits of the process before it was successfully introduced in practice. Still other concurrent conditions were requisite to secure its establishment on a firm basis. These were: an available supply of suitable ores, and, not less important, trained metallurgists who saw a value in the process and were able and willing to tackle and overcome the constructional and manipulative details incident to all new metallurgical processes.

The process was first introduced at particularly favored localities. The discussion of the subject by American metallurgists[2] shows in what measure the process was utilized under less favorable conditions and indicates the modifying effect of local conditions.

Before attempting to employ the process in zinc metallurgy, its development in copper smelting should be carefully studied.

### Data Available and Required

Fortunately, the chemical and physical data are readily available. Some laboratory experiments are desirable in working out some of the problems involved. With the great extension of facilities for this work furnished by government, university, corporation, and private metallurgical and test laboratories, it is to be expected that this need will be recognized and filled. Some of the determinations required reach to the very essence of pyritic smelting, and will supply much needed data; for example, the determination of the effect of increasing the temperature of blast and of the rate of blowing; the composition of issuing gases; the fusibility of definite charge mixtures; the separation of matte, and the expulsion of zinc from slag and matte.

### Experimental Apparatus Suggested

I subjoin for present reference a few constants involved in the study of pyritic smelting, and submit several sketches illustrating simple laboratory apparatus by means of which many results of value should be obtained. Anyone accustomed to laboratory experiments can readily improve upon the construction shown. I hope the ideas involved will be suggestive of such improvements. Fig. 1, mainly diagrammatic, shows an air meter with a tightly fitting piston, the displacement of which is read on the graduated piston rod. The pressure is regulated by the weight applied to the cross-arm, which carries the guides to ensure parallel motion. Connected with this is the blast pipe *D* containing a thermometer *E* and a pressure gauge *F*, which may be a spring gauge measuring ounces, or a simple tube measuring inches of waterhead; beyond these, on the pipe line, should be located an electric heater for the blast, shown separately at *N*, and a thermopile, represented by *O*, to measure the temperature of the heated blast. With a proper gas valve in the air pipe beyond this, and the ordinary ammeter and voltmeter connected with the electric heater, the efficiency of various electric heaters, as affected by the volume of the blast, could be readily measured. This apparatus, connected with the inner crucible *H* would be sufficient to conduct many experiments in sinter-roasting, clinkering and volatilization on commercial grades of ores, as well as on selected mixtures, with and without additions of carbonaceous fuels and fluxes. The crucible *H* should be inclosed in a larger crucible and the space between them packed with a heat insulator. The detached cover *J* of the inner crucible, with the goose-neck *K*, the equalizing tube *L* and the discharge tube *M* shows the manner of drawing off the

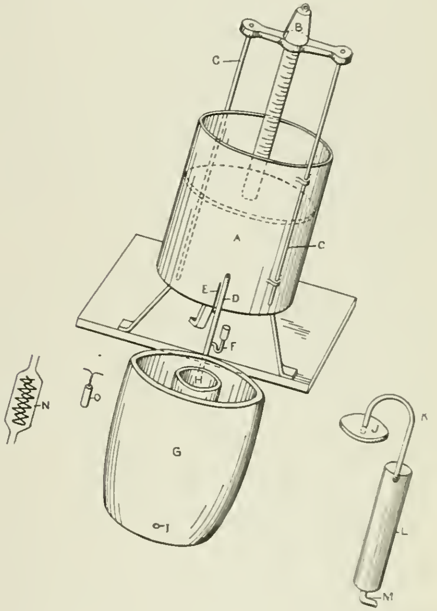


FIG. 1—APPARATUS FOR STUDY OF PYRITIC PROCESSES

evolved gases and sublimation products for analysis.

---

[1] This journal, April, 1914, p. 250.
[2] Pyritic Smelting, *Eng. & Min. Jnl.*, Oct. 10, 1903, et. seq.

A better arrangement for the inner crucible is shown in Fig. 2, where it is set in a sand-bath held in a metal pan, and is surrounded by a non-conducting cylinder notched at the bottom to slip over the air and tapping pipes. The space between the crucible and cylinder should be filled with mineral wool or other heat insulator. The sand-bath forms a good seal to the space between crucible and cylinder, and it should be heated externally to about the temperature of the gases issuing from the top of the crucible, to overcome the excessive radiation from the small apparatus employed.

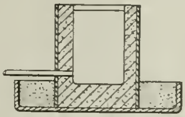


FIG. 2—ARRANGEMENT FOR INNER CRUCIBLE

Fig. 3 shows a better form of air meter, and there should be two of them, with alternate connections; so that while one is being emptied, the other could be filled from an air pump or blower.

Fig. 4 shows an arrangement of crucible for a melting charge, furnishing bullion, matte, or slag, or all of them, by means of which the melted product is removed from in front of the tuyeres. *C* is a lower crucible answering the purpose of a fore-hearth. At the start, it functions as an air chamber on the blast system; as it gradually fills up, the air is expelled. It may be discharged by the bottom plug *H*. The function of the sand-bath *F* and the insulation around the crucible is simply to offset the excessive radiation loss from a small crucible. If its temperature is not above that of the issuing gases, the added heat has no other effect on the charge in the crucible.

### Results to Be Obtained from Experiments

With this apparatus, the operation can be made nearly continuous with a dried-out charge, and slagging and matting operations can be carried on, and the behavior of various carbonaceous fuels, charcoal, coke, lignite, and anthracite, can be observed, when added to the charge. With the whole apparatus the effect of blast temperature and of the rate of blowing can be measured with reasonable accuracy, and by analyses of the products at observed intervals, and analyses of the original charge, a control can be had over what has actually taken place in the furnace.

The results of these measurements cannot fail to be of value to metallurgists having to do with desulphurizing, volatilizing, sintering, clinkering, fluxing, slagging, matting or smelting various furnace charges. These results will give some indication of the metallurgical value of various fuels, and will probably determine the lines on which the igneous concentration of zinc from mixed sulphides should be planned and undertaken on a commercial basis.

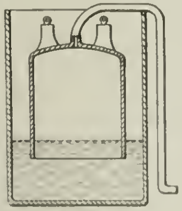


FIG. 3 FORM OF AIR METER

To get the net evolution of heat from the oxidation of a pound of zinc existing as sulphide, deduct the heat of combination of one pound zinc with sulphur, from the sum of the heats of combination of the zinc and sulphur with oxygen. With one pound of zinc there is associated practically one-half pound of sulphur. The burning of this to $SO_2$ will furnish an additional amount of 1916 B.t.u. evolved in the transformation. To get at the heat evolved per unit of oxygen, divide the heat evolved per unit of zinc by the oxygen required to oxidize zinc, called unity, plus the percentage ratio of oxygen required to oxidize the combined sulphur.

The heat of combination of definite substances is given in text books, as calculated for a different weight of each substance. These different weights are called molecular weights. That is, they are proportional to the weights of two substances which combine to form a compound.

This is a convenient form for metallurgical calculations. The metric system of weights and measures offers great facility in calculation, but because American engineers generally use the pound avoirdupois and the British thermal unit, to express the thermal value of fuels, I have arranged Table 1 in these units.

It should be explained that the figures given in all tables record the amounts of heat given out by the compounds in cooling to somewhat conventional temperatures, which may be either room temperature, or zero Fahrenheit, or zero Centigrade, or absolute zero.

In all metallurgical operations, the heat carried off in the escaping gases is necessarily lost to the furnace. In any particular case we can calculate what heat is thus lost, if we know the composition, weight and temperature of the escaping gases.

This heat they would give up in the calorimeter, if they were cooled to the starting point of the tables. Therefore, this unavoidable loss should be deducted from the values given in the tables, to get at the metallurgical value of any particular fuel. It is impossible to make tables for all temperatures of all gases, but in general the correction to be made in comparing fuel values is slight.

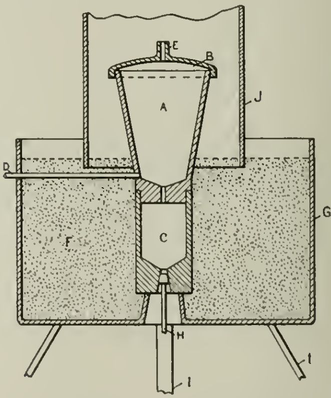


FIG. 4—APPARATUS FOR STUDY OF SMELTING CHARGES

The exception is, where a change of state occurs in one or more of the gases, at a temperature below that at which it escapes from the furnace. This change of state corresponds to the condensation of steam, which gives out a notable amount of heat that is registered in the calorimeter, but is not available in the furnace for the reason that the issuing gases have a temperature above the boiling point of water. It is proper, then, to deduct the latent heat of the water formed from the heat of combustion of carbonaceous fuels. It is well known that these fuels differ greatly in the amount of water formed by their complete combustion. A representative value of the calorific value of commercial coals must, therefore, be arbitrarily chosen.

The calorific value of any substance may be measured for a unit of that substance, or for a unit of oxygen, or of air, required to burn it. A comparison of these measures is often of interest.

In Table 2 I have deducted the heat of combustion

TABLE I

| COMBINED WITH | | GIVES | AND EVOLVES |
|---|---|---|---|
| One Lb. of | Lb. of | Lb. of | B.T.U. |
| Zinc | Oxygen<br>0.246 | $ZnO$<br>1.246 | 2,871 |
| Iron | Oxygen<br>0.286 | $FeO$<br>1.286 | 2,111 |
| Copper | Oxygen<br>0.252 | $Cu_2O$<br>1.252 | 1,667 |
| Copper | Oxygen<br>0.126 | $CuO$<br>1.126 | 620 |
| Carbon | Oxygen<br>1.333 | $CO$<br>2.333 | 3,281 |
| Carbon | Oxygen<br>2.667 | $CO_2$<br>3.667 | 14,580 |
| Hydrogen | Oxygen<br>8.000 | $H_2O$<br>9.000 | 52,254 |
| Sulphur | Oxygen<br>1.000 | $SO_2$<br>2.000 | 3,895 |
| Oxygen | $Zn$<br>4.062 | $ZnO$<br>5.062 | 11,662 |
| Oxygen | $Fe$<br>3.500 | $FeO$<br>4 500 | 7,381 |
| Oxygen | $Cu$<br>3.975 | $CuO$<br>4 975 | 6,626 |
| Oxygen | $Cu$<br>7.950 | $Cu_2O$<br>8.950 | 4,929 |
| Oxygen | $C$<br>0.750 | $CO$<br>1.750 | 2,460 |
| Oxygen | $C$<br>0.375 | $CO_2$<br>1.375 | 5,868 |
| Oxygen | $S$<br>1 | $SO_2$<br>2.000 | 3,895 |
| Oxygen | $H$<br>0.125 | $H_2O$<br>1.125 | 6,709 |
| Iron | $S$<br>0.554 | $FeS$<br>1.554 | 771 |
| Zinc | $S$<br>0.492 | $ZnS$<br>1.492 | 1,191 |
| Copper | $S$<br>0.503 | $CuS$<br>1.503 | 286 |
| Sulphur | $Zn$<br>2.031 | $ZnS$<br>3.031 | 2,419 |
| Sulphur | $Fe$<br>1.750 | $FeS$<br>2.750 | 1,350 |
| Sulphur | $Cu$<br>1.988 | $CuS$<br>2.988 | 569 |
| Sulphur | $Cu$<br>3.975 | $Cu_2S$<br>4.975 | 1,142 |

TABLE II

| COMBINED WITH | | GIVES | AND EVOLVES | ALSO GIVES | EVOLVES | TOTAL | ABSORBS | NET |
|---|---|---|---|---|---|---|---|---|
| One Lb. of | Lb. of | Lb. of | B.T.U. | Lb. of | B.T.U. | B.T.U. | B.T.U. | B.T.U |
| $ZnS$ | $O$<br>0 495 | $ZnO$<br>0.835 | 1924 | $SO_2$<br>0 66 | 1285 | 3209 | 798 | 2411 |
| $FeS$ | $O$<br>0 650 | $FeO$<br>0 922 | 1343 | $SO_2$<br>0.728 | 1418 | 2761 | 491 | 2270 |

To burn completely 1 lb. $ZnS$, requires 0.495 lb. of oxygen for zinc and sulphur, and develops 2411 B.T.U. of available heat.

To burn completely 1 lb. $FeS$, requires 0.650 lb. of oxygen for iron and sulphur, and develops 2270 B.T.U. of available heat.

To burn 1 lb. of carbon to $CO_2$ requires 2.667 lb. of oxygen and develops 14,580 B.T.U. of available heat.

To burn 1 lb. of carbon to $CO$ requires 1.334 lb. of oxygen and develops 3281 B.T.U. of available heat.

It then requires about 6 lb. of $ZnS$ to replace 1 lb. of pure carbon burnt to $CO_2$, but only about 1 1-3 lb. if burnt to $CO$.

Heat developed per lb. of oxygen for $ZnS$ is $\frac{2411}{0\ 495} = 4870$ B.T.U.

Heat developed per lb. of oxygen for $FeS$ is . . $\frac{2270}{0\ 650} = 3492$ B.T.U.

Heat developed per lb. of oxygen for $C$ to $CO_2$ is $\frac{14,580}{2\ 667} = 5467$ B.T.U.

Heat developed per lb. of oxygen for $C$ to $CO$ is $\frac{3281}{1\ 334} = 2460$ B.T.U.

of a compound, which must be broken up before its components can be separately oxidized. Thus, if both the sulphur and the iron in the compound FeS are to be oxidized, and it takes a certain amount of heat to dissociate the sulphur from the iron, it is only the difference between this amount of heat, and the sum of the heats developed by the oxidation of the separated components that can be utilized. All of the figures given in the table are derived from those given in Dr. J. W. Richards' Metallurgical Calculations, and are referred to the temperature of 15 deg. C. (59 deg. F.) and to normal pressure.

A glance at the tables will show that zinc sulphide compares very favorably with iron sulphide, as a metallurgical fuel, and makes a good showing when compared with partly burned carbon. It is scarcely worth while to spend time and labor in theorizing or in figuring on conditions, which must be imagined.

What is wanted are data, which can be determined only by experiment. It is seldom that the carbon in metallurgical operations is completely burned to carbon dioxide. This indicates the importance of analyzing the gases which escape from the furnace; for a deduction from the calorific value of the carbon must be made for any portion of it which escapes as carbon monoxide. Coal can be credited with only that amount of hydrogen which is not combined with oxygen; for it takes just as much heat to dissociate the water, as the hydrogen thus liberated will produce by burning.

Sulphide of iron is not a common constituent of ores. The bi-sulphide is the common mineral. The second atom of sulphur is distilled off before the smelting zone is reached. It is generally accepted that the sulphur thus freed is no aid to pyritic smelting. Even if it is burned to $SO_2$ in the furnace, the heat is given out where it is not needed. On the other hand this free sulphur is objectionable: (1) because its expulsion renders latent an unknown amount of heat; (2) because it requires an additional amount of oxygen and consequently of air, to be blown into the furnace.

To furnish 1 lb. of oxygen very nearly 4 1/3 lb. of air are required. An increased weight of issuing gases carries an increased amount of heat out of the furnace for the same temperature of escape. The consequent dilution also lowers the temperature at the focus of the furnace.

From the history of the introduction of pyritic smelting into the metallurgy of copper, it may be safely predicted, that, as a concentration process for the treatment of zinc ores it can only be introduced at some favored locality where a supply of suitable ores is assured; and even then it must await the arrival of the man and of the hour.

Lead sulphide, if present in considerable amount, will add some complications. But the bulk of galena can be removed by simple jigging before concentrating the zinc. If gold and silver are present, they will go mainly into the lead bullion or the matte. The small amounts which go off in the sublimed product can be recovered from the rich zinc sublimate. If no bullion or matte is produced, it will require an analysis of the slag to determine whether it will pay to add it to the charge of a lead furnace.

I have barely touched upon the problems which can be solved in the simple apparatus here shown. There are many other data, pertaining to pyritic smelting in general, which it is very desirable to have in hand.

Denver, Colo.

---

**The Kieselguhr Company of America**, Los Angeles, Cal., has issued an interesting booklet on "Sil-O-Cel, Nature's Non-Conductor," describing the uses of kieselguhr products. Sil-O-Cel is now finding application in the insulation of heat in electric furnaces and similar apparatus where the cost of fuel and power is an appreciable item of expense, but only a small part of which is actually consumed in the operation. Among the varied uses of Sil-O-Cel may be mentioned the heat insulation of all sorts of heating appliances, cold storage and refrigerating apparatus; the sound-proofing and fire-proofing of walls, floors and structures. Sil-O-Cel consists almost wholly of silica and is very light in weight.

## Rapid Method for the Determination of Chromium in Pig Iron, Cast Iron and Steel

BY H. E. WALTERS

Owing to the general tendency to add alloys or pig iron containing chromium to mixtures for iron castings, it has become necessary for foundries which control their product by chemical analysis to insist on the determination of the amount of this element in the scrap or pig iron used in the mixtures.

The methods given in the text books for the estimation of chromium require too much time for routine determinations and the writer felt that a method of his published some years ago (American Chemical Society Journal, Vol. XXVII, p. 1550 to 1553) could be modified so that a rapid and accurate determination could be made.

Experiment proved this to be the case and the method is used daily.

After working up the method, a search of the literature was made and it was found that a method practically identical was published by M. Phillips (*Stahl und Eisen*, Vol. XXVII, p. 1164 to 1167).

Credit for priority is, of course, due to Phillips, but as the journal used for the publication of his paper is consulted by but a few American chemists the writer feels that a description of the method will be welcome to chemists who are called upon to make this determination.

### Method

Weigh two grams of the sample into a No. 3 beaker, add 60 cc dilute sulphuric acid, cover with watch glass and heat until sample is in solution. Add 6 cc nitric acid 1.20 Sp. Gr. to oxidize the iron, and boil about two minutes. Filter into a No. 5 beaker and wash four or five times with hot water, the volume of the solution should then be about 125 cc.

Place over a light, add 5 cc silver nitrate solution and about five grams ammonium persulphate and heat to boiling, the manganese should be oxidized to permanganic acid and this may decompose into manganese dioxide. (If permanganic acid is not formed, more persulphate must be added as the formation of the permanganic acid insures the oxidation of the chromium). Boil about five minutes to destroy excess of persulphate, add 2 cc conc. hydrochloric acid and continue the boiling five to ten minutes to expel chlorine. Cool, dilute to about 400 cc with water, add a measured volume of a standard solution of ferrous ammonium sulphate to reduce the chromic acid, titrate the excess of ferrous iron with a standard potassium permanganate solution.

The number of cubic centimeters of the permanganate solution used subtracted from the number required for the volume of ferrous sulphate added, will give the volume of the permanganate solution equivalent to the chromium.

### Reagents and Remarks

*Sulphuric Acid*—A mixture of one part concentrated acid and five parts of water.

*Silver Nitrate.*—Four grams of the salt are dissolved in one liter of water.

*Ammonium Persulphate.*—The salt should be slightly moist.

*Permanganate Solution.*—The solution is made by dissolving 3.64 grams of pure potassium permanganate in water and diluting to one liter.

*Ferrous Sulphate Solution*—The solution is made by dissolving 45 grams ferrous ammonium sulphate in water, adding 50 cc conc. sulphuric acid and diluting to one liter.

It is unnecessary to have this solution exactly equal the permanganate solution, as a constant volume is used and the solution loses in strength. It is only necessary to find the volume of permanganate equivalent to the volume of ferrous sulphate used and this should be done every day.

25 cc of this solution will be ample for chromium up to 2 per cent when working on a two gram sample.

The permanganate solution may be standardized by finding the iron value, or by use of a pure chromium salt or sorensens sodium oxalate.

If the solution is standardized against iron the chromium value is found by the equation:

167.52:52.0 :: Iron valuue: $X$ equals chromium value.

If sodium oxalate is used the chromium value is obtained by the following calculations:

Weight of sodium oxalate $X$ .2587 equals weight of chromium. Weight of chromium divided by cc used for sodium oxalate equals value of 1 cc in terms of chromium.

In using the method on high silicon irons a few drops of hydrofluoric acid should be added while the sample is dissolving.

The method will be found very rapid for steels as no filtration is required.

I have encountered no difficulty on account of the presence of chlorides in making the titration with permanganate, and any chance of trouble from this source can be eliminated by adding the titrating mixture used in the determination of iron in the presence of hydrochloric acid.

United Engineering and Foundry Company, Lincoln Foundry Company Dept., Pittsburgh, Pa.

---

## New Buildings for United States Bureau of Mines at Pittsburgh

Plans for the proposed $500,000 experiment station of the United States Bureau of Mines to be located in Pittsburgh, Pa., have been approved by the commission appointed by Congress for that purpose. The Federal Government now owns the property upon which will be erected a group of buildings, especially designed and adapted for the carrying on of the mine-safety work and other investigations in which the Bureau of Mines is interested.

The group consists of three main buildings, the central or mining building, having three stories, flanked by the mechanical and the chemical buildings. In the rear of these and inclosing a court will be the service building.

Between the main group and the power and fuel group will be the entrance to a series of mine shafts. One of these will be used as an elevator to carry heavy material and passengers from the lower level to the upper; another will be for tests of hoisting ropes and similar mining appliances; another will be an entrance to tunnels extending under the buildings and in which mining experiments, such as fighting mine fires, will be conducted.

Congress a year ago, in the public buildings bill, authorized a new home for the Bureau of Mines to cost $500,000. It is now expected that Congress in its present session will make a specific appropriation so that construction work may begin. It is hoped that contracts may be let by July 1. The director is hopeful that the buildings may be completed in the fall of 1915.

---

**Liquid Flow Recorders.**—The Yarnall-Waring Co., of Philadelphia, Pa., have just published a list of over 1000 users of the Lea V-Notch recording liquid meters.

# Blast Furnace Blowing Apparatus

BY J. E. JOHNSON, JR.

(Concluded from page 242, April issue.)

## Steam Valves and Their Settings

The conditions as to the steam valves for blowing engines are no different from what they are in any other type under similar conditions of size, speed, and economy desired. It is therefore obviously unnecessary and undesirable to go into an extensive discussion of this subject here.

In American practice the Corliss valve has won its way to almost exclusive use in high-grade steam engines. The poppet valves, which have given magnificent results in Europe, have never become popular in this country in spite of the economical results which have been obtained with them. It is probable that the conditions of operation are somewhat more exacting with that type of valve on account of its coming against a rigid seat, than they are with the Corliss valve with its rotating motion and absence of sudden stops. At all events the result is as stated, that the Corliss valve gear is preeminent in all the modern blowing engines in service and being built in America at this time.

The original Corliss valve gear was subject to the disadvantage that if the cut-off did not occur at a point somewhat before half stroke it did not occur at all, and steam followed full stroke with utter destruction of economy and terrific stresses on the engine.

With engines on constant mill loads, and particularly before the introduction of the compound which divided the expansion between two cylinders and greatly retarded the point of cut-off in each, this was generally not objectionable, but with the relatively late cut-off necessary for the compound engine, the variable loads to be met, and variations in the steam pressures owing to irregular conditions, so limited a cut-off was not satisfactory for blowing engines, so that for several years makers have been adding an eccentric which enables cut-off to take place under the control of the governor at any point up to about eight-tenths stroke in the high-pressure cylinder, and this constitutes a great advantage under operating conditions, so much so that no engine should be installed for furnace work without it.

Theoretically the low-pressure cylinder does not need the long range cut-off so much, but practically the necessity of operating even though steam pressure be down, and the low-pressure cylinder doing most of the work, makes it very desirable to have this gear on the low-pressure cylinder also, and personally I should not recommend any furnace man to buy a blowing engine not so equipped.

This feature is also of great advantage in starting an engine up from any position in which it may stop without barring it over, and in a heavy engine this is a convenience well worthy of the expense.

The resultant diagrams, Figs. 17, 18, 19 and 20,* indicate certain features as to the stresses in engines which are worthy of attention. It is proper to say that engineers are by no means unanimous on some of these points, and for that reason the views which I shall express are simply my own and are undoubtedly not in accordance with those of some others well qualified to pass on the subject.

There will be seen at the left of Fig. 8 a sharp point extending about 20 lb. per sq. in. below the line or zero pressure at the beginning of the stroke, which runs down to nothing at about 5 per cent of the stroke. This pressure comes from the re-expansion of the air left in the clearance space of the air cylinder, which, of course, is *in the same direction* as the pressure of the steam in the steam cylinder at that time. As soon as the pistons have moved a short distance this air re-expands down to atmospheric pressure, and thereafter the rising pressure in the other end of the air cylinder is increasingly opposed to the steam pressure. It will be seen that if the steam reached full pressure in the steam cylinder at the moment the stroke started, as is customary and proper in power engine practice, there would be practically double pressure on all the reciprocating parts and on the engine frame at this point, at which the velocity of the piston for a given amount of crank travel is very slow, so that this excessive pressure would come at a time to produce the least useful and the most frictional effect.

Inspection of the diagram, Fig. 3, will show that the engine builder has prevented this in part by delaying the admission of live steam so that it does not reach full pressure until after the piston has moved an appreciable distance, by which time the pressure of air in the clearance space is considerably diminished by re-expansion. For this reason the combined net pressure diagram of air and steam cylinders (Figs. 17 and 18) instead of showing a sharp "spike" on the left-hand end of the diagram, as it would if steam were admitted to full pressure at the beginning of the stroke, shows only a considerable "hump." The practice in the case of the low-pressure diagram of the same set (Fig. 5) is even better in this respect, for it will be seen that in this case the piston has traveled the whole distance necessary to permit complete re-expansion of the air before steam reaches full receiver pressure in the cylinder, and if a combined diagram were made for these cylinders the hump at the left, shown in Figs. 18, 19 and 20, would not appear.

Following through this same idea these builders eliminate any compression whatever, both in the high-pressure and low-pressure cylinders. In fact, there is nothing in either diagram to show that the steam first admitted at the beginning of the stroke may not blow through into the exhaust. It is not possible to say from the indicator diagram that it does so, and the care and good judgment of the builders make it unlikely, at the same time so considerable an economy of steam may be effected by very little compression, and with such a slight increase in pressure, that I consider a small amount of compression desirable both for the steam it saves and to make it absolutely certain that live steam does not blow through into the exhaust at the beginning of the stroke.

It will be noted that in this diagram (Fig. 5) and also to a less extent in Fig. 3, the exhaust of the steam is extremely slow. The exhaust valve does not open at all until the end of the stroke is reached, and the steam consequently has little time to leave the cylinder while the engine is turning the center. The result is the sharp "toe" at the exhaust end of the diagram, which in my judgment should come down as shown in dotted lines, very materially increasing the area of the diagram without any ill effect.

Turning now to the Southwark engine cards shown in Fig. 26 we see practice the exact opposite of that of the Tod company in these particulars. The compression pressure rises nearly half way to receiver pressure and admission is so early that full receiver pressure is reached at the very beginning of the stroke.

On the other hand, the exhaust is early, so that full vacuum is reached almost at the very beginning of the exhaust stroke, as it should.

If combined net pressure diagrams were made of this set of air and steam cards there would be found a "spike" of pressure at the beginning of each stroke which would just about double the total pressure on all the running gear and the engine frame for a brief instant of time at which it could deliver no useful work, owing to the low angle of the crank at that position, but in which it could greatly stress all the running gear and the frame of the engine itself and produce excessive wear if not an absolute hammering down of the brasses. Cases are on record in which certain engines of the walking-beam type broke their frames or pedestal caps repeatedly as long as the steam valves were set to give "lead"; that is, to give full pressure of steam at the beginning of the stroke, but which quieted down and ran without further difficulty when admission was delayed to compensate for the re-expansion in the air cylinders.

---

*See April issue for illustrations 1 to 27.

It will be seen, therefore, that the practice of the William Tod Company and of the Southwark Company is at the two opposite extremes in this respect. The Tod Company uses no compression and delayed admission, the Southwark uses heavy compression and early admission.

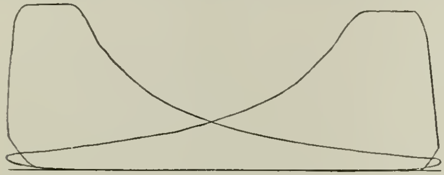


FIG. 28—STEAM CARD TAKEN FROM MESTA LONG CROSS-HEAD BLOWING ENGINE

I am able, through the kindness of the Mesta Machine Company of Pittsburgh, to present a pair of cards taken from one of their long cross-head blowing engines which seems to me to embrace the best practice in both respects. There is enough compression to reduce the total steam consumption appreciably, as can be judged by noting the percentage of the stroke still remaining to be made when compression begins; and then delays the admission sufficiently to allow full time for the re-expansion of the air in the clearance space.

In my judgment these cards are illustrative of the practice which should be followed by every blowing engine operator in setting the valves on his blowing engine. It will be noticed that the early closing of the exhaust valve has its complement in the sufficiently early opening of these valves to prevent any loss of area by failure of the steam to exhaust promptly.

In general it may be said that the blowing engine should be indicated at intervals of a few months to prevent or correct the multifarious misadjustments which can arise from many causes, many of which lead to bad economy and others to excessive stresses similar to those I have described and worse.

At plants where the economy of steam is not a prime consideration the hideousness of the steam practice which may prevail and still let the plant operate is beyond belief by those who have not seen it. There is probably no field about the plant where so small an investment of time and trouble will pay so great a return in steam economy and repair expenses avoided.

## The Turbo Blower

Within the last ten years the general introduction of the steam turbine and the high efficiency to which it has attained have brought about a great development in centrifugal machinery. It was formerly supposed that centrifugal fans were of no value for pressures above 1 lb. per square inch, and they were seldom or never compounded by putting two fans in series so as to increase the pressure they could attain. Instead, if a pressure of more than a few ounces was desired, the tendency was to pass to the use of the positive pressure blower.

The French engineer Rateau deserves the credit for working out into practical shape the use of the series fan capable of blowing pressures suitable for blast furnaces, and introduced several of these machines in Europe about eight or nine years ago.

Blast pressures in Europe are commonly not so high as those in this country, so these blowers were not suitable for American conditions. Moreover, it has been found to be universally the case that when a prime mover was introduced from Europe into America it had to be redesigned to meet American ideas and American conditions. This has been the case with the turbo blower. The first of these machines in this country was built by the General Electric Company for the Oxford furnace of the Empire Iron & Steel Company, and was started in 1910. A twin machine was started a few months later at the furnace of the Northern Iron Company at Port Henry, N. Y. Probably the largest single installation of these machines to date is that of the Iroquois Iron Company at Chicago, where the sole blowing power for two furnaces consists of three turbos with a capacity of 40,000 cu. ft. per minute each to a pressure of 30 lb.

More recently the Southwark Foundry & Machine Company has introduced the Rateau style of turbine into this country, and has already built several of them.

The Westinghouse Machine Company has as yet built no multistage turbine, but has built some single-stage machines for a pressure of 5 to 7 lb., these not being used in the iron industry, but under similar conditions in other industries.

The theory of the turbo blower is extremely simple. Air is admitted around the shaft, caught by the rapidly revolving vanes, or blades, of the fan, and has imparted to it a high velocity. This velocity is transformed into pressure, and the method by which this may best be done is a subject of some dispute among the designers of this class of machinery. The pressure obtainable in any one stage is limited by the speed which may be attained by the fan, and this is virtually the speed at which it is safe against the influence of centrifugal force.

The discharge from one fan is lead around through an annular port in the casing to the center of the next fan, which increases its pressure by a similar amount, and then to a third, and so on.

The number of stages to be used is not definitely settled. The Rateau blowers use eight, the first General Electric blower used six, but in the more recent types of construction the latter company have diminished the number of fans in series to three by increasing the speed.

The pressure increases more rapidly in the later stages than in the earlier ones because the density is increased by the increasing pressure.

The work put upon the air in compressing it heats it exactly as it does in a piston-blowing engine, but to a greater extent because the efficiency of the operation is lower with greater losses of energy in eddy currents, etc., which are eventually converted back into heat. The casings are therefore cored out hollow and cooled by water circulation to keep down the temperature of the air.

### THE SOUTHWARK TURBO BLOWER

The internal construction of the Rateau machine as built by the Southwark Company is shown in Fig. 29. The U-shaped discharge passages by which the air discharged from one fan is delivered into the central aperture of the next are clearly shown. In this turbine there are fans or impellers in two groups of four each, the inlet of the first group being next to the central bearing between the two sets. The air then progresses to the left and is discharged into a receiver pipe which carries it over into the inlet of the second group next to the inside bearing, and it then progresses outwardly through this group to the discharge at its right-hand end. In this way the end thrusts against the two sets of impellers are balanced against one another so as to throw as little work as possible on the thrust bearing.

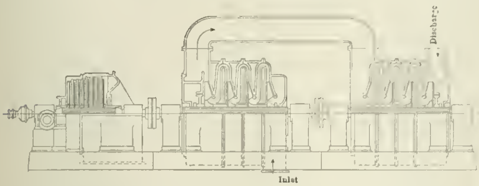


FIG. 29—SOUTHWARK RATEAU TURBO BLOWER

The turbine which drives the blower is shown in half section at the extreme left. The shafts for the turbine, and the two sections of the blower are all separate, and coupled together by flange couplings to permit an absolute alignment of each shaft in its own bearings. The shaft is located endwise by a thrust bearing at the left-hand end of the turbine shown in Fig. 30. This thrust bearing is capable of being moved and can be adjusted by a hand-wheel and screw to secure proper clearance and operation. The general arrangement of this machine is well shown by Figs. 31 and 32.

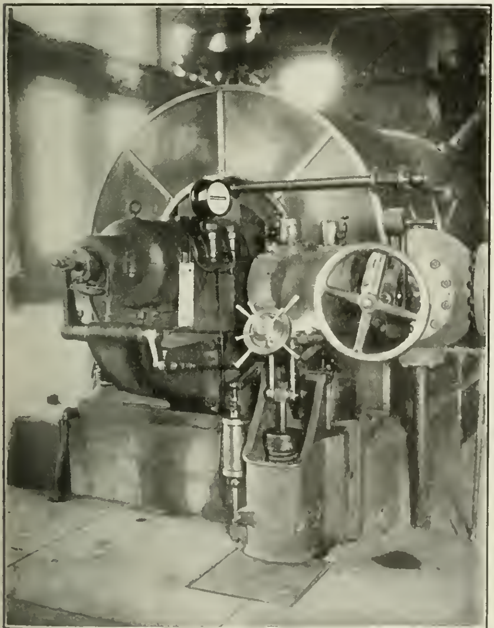


FIG. 30—STEAM END GOVERNING APPARATUS AND THRUST BEARING ADJUSTMENT, RATEAU TURBO BLOWER

The details of the design of the impeller, casings, etc., are highly technical matters in which mathematical theory and elaborate experimentation must go hand in hand to get the best results. To the great majority of users the only question of importance is how much steam is required to deliver a given quantity of blast at a certain pressure, and the details of the methods by which the guaranteed results are obtained is a matter of indifference to them and I make no attempt to treat of these matters, because it seems to me outside the field of the present work.

The turbo blower is of course entirely valveless, and it therefore escapes the troubles of valve design and operation which I have briefly described in connection with reciprocating engines. It is also entirely without anything comparable to the piston displacement of the reciprocating blowing engine. That is, it has no metering effect, and its speed is accordingly no gage whatever of the quantity of wind it is delivering under given conditions. It is the function of a blower or centrifugal pumping apparatus of any kind to produce pressure and the flow which results is proportional to the difference maintained between the pressure at the discharge of the apparatus and the pressure in the vessel into which it discharges. If a reciprocating blowing engine, running at a certain speed, delivered the desired amount of air to a furnace at say 15 lb. pressure, and if the resistance of the stock in the blast furnace suddenly fell so as to let the pressure drop down to 14 lb., it would make little or no difference in the quantity of wind delivered by the engine, but with the turbo blower it would make an enormous difference, because it would endeavor to maintain the same discharge pressure, and with the pressure difference between this and the resistance of the furnace increased by the drop in the latter, the flow would be greatly augmented. For this reason the turbo blower requires a governing device which shall control the quantity of air passing through it.

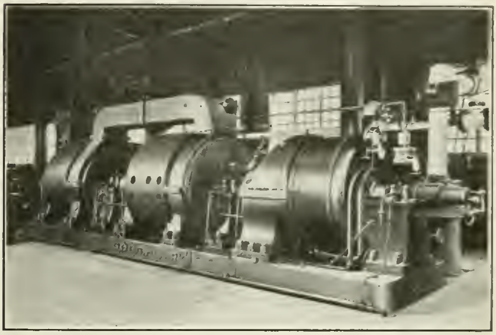


FIG. 31—SOUTHWARK RATEAU TURBO BLOWER

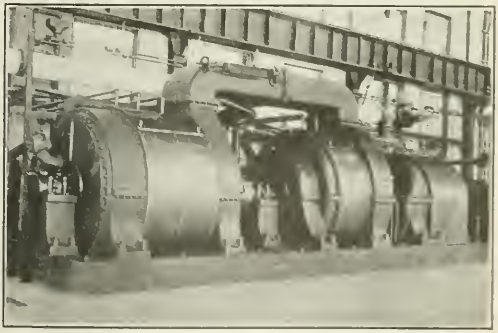


FIG. 32—SOUTHWARK RATEAU TURBO BLOWER

In the Rateau system the well-known principle of the

Venturi meter is used. In this an inlet pipe is provided which has a relatively small throat approached by a gradual taper and followed by an expanding taper to the normal diameter of the pipe. The difference in the velocity of the air at this throat and in the large area behind it, gives rise to a difference in pressure at these points which depends upon the velocity of the flow, and by measuring the pressure with a differential gage the flow can be accurately calculated and controlled. The arrangement is shown diagrammatically by Fig. 33. The partial vacuum at the throat of the Venturi meter is maintained constant by means of a relay working on the steam governor of the turbine. If the flow increases the vacuum in the throat of the Venturi tube increases, and this acting through the relay cylinder operates on the steam valve of the turbine and reduces its speed, which in turn reduces the difference in pressure maintained by the blower, until the quantity of air flowing through it is reduced to the amount desired. A centrifugal governor is interconnected with the same system so as to close the steam valve entirely in case of excessive speed.

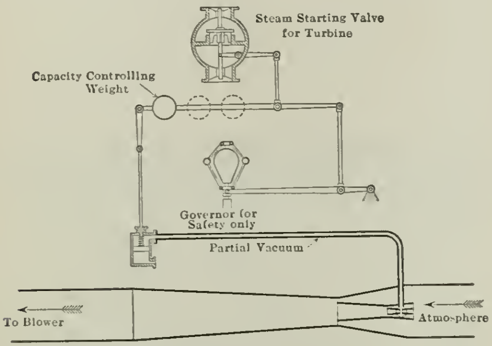


FIG. 33—METHOD OF CONTROLLING CAPACITY OF RATEAU TURBO BLOWERS—SOUTHWARK FOUNDRY & MACHINE COMPANY, PHILADELPHIA, PA.

### THE GENERAL ELECTRIC BLOWER

The principle of this blower is the same as that of the Rateau, but the number of impellers used is smaller, and the whole of the blower is built in one body, without the feature of balancing by having the flow from the two half sections of the impeller in opposite directions. This produces a shorter and more compact machine. This blower is shown by Figs. 34, 35, 36, 37 and 38, taken from a paper on the "Turbo Blower" presented by Mr. Richard H. Rice, of the General Electric Company, before the American Institute of Mining Engineers, and published in their Bulletin for May, 1914.

The governing device of this machine is on a somewhat different principle from that of the Rateau; it is shown by Fig. 34. The inlet pipe ends in a large inverted cone in which a circular diaphragm is suspended from a beam overhead. It is obvious that the area of the annular space between the diaphragm and the walls of the cone will vary with the location vertically of the diaphragm, and that the flow of the incoming air up past this diaphragm will have a tendency to lift the latter varying with the velocity of the air through the annular space, and the governing is done by the varying lift of this diaphragm. Thus while a different mechanism is used it produces about the same resultts as the Venturi tube.

If the pressure required by the furnace increases so as to decrease the flow of air under the speed at which the turbine is running, the diaphragm promptly drops down carrying with it the beam which operates on the steam valves, admits more steam and increases the speed of the turbine until the flow of air is restored to the normal. In this turbine also a centrifugal governor is provided to prevent excessive increase in speed.

The advantages of the turbo-blower are its small size, its entire freedom from reciprocating parts, and consequent ability to dispense with any but a light foundation, the small number of moving parts, *there being in effect but one,* and its ability to dispense with lubricating oil both in the steam and air ends. Great advantages are claimed for it also in the absolute steadiness of the blast which it produces, and the freedom from pulsation which results from a continuous discharge.

In the paper by Mr. Rice above mentioned he describes researches which prove the absence of such vibrations with the turbo blower, and their presence with reciprocating blowing engines, but whether this absence may be translated into dollars and cents of advantages in operation is a matter concerning which no proof has as yet been offered and concerning which I confess a considerable degree of skepticism.

It is claimed without hesitation that these blowers on account of the steadiness of their action, etc., enable a furnace to produce less flue dust and to make iron with less fuel than can be done with any other type of blowing machinery, but no definite data on this subject have been offered to support this contention, which also seems to me doubtful.

Fine points of this kind are always exceedingly difficult to prove in an operation of such magnitude as the blast furnace, and the situation is complicated by the fact that the turbines have in the nature of things, in many places at least, replaced obsolete blowing engine installed under bad conditions and therefore likely to be drawing steam into their inlet and discharging it into the furnace along with the air, with consequent detriment to fuel economy. Moreover, these engines being

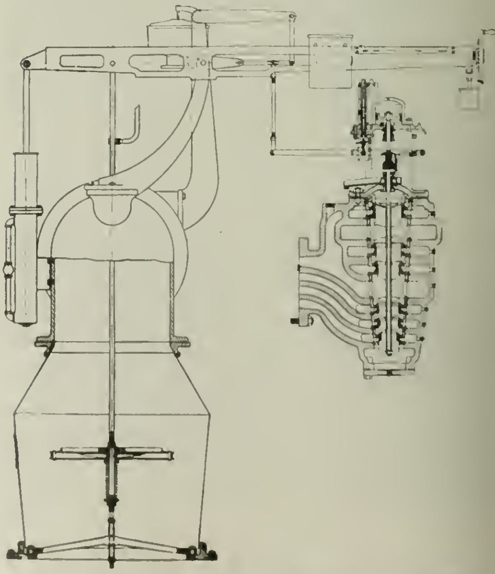


FIG. 34—CONSTANT VOLUME GOVERNOR FOR CENTRIFUGAL COMPRESSORS

old and uneconomical, and being presumably of the low-speed variety, they gave greater pulsation to the blast than more modern and higher speed engines. It is therefore extremely doubtful whether the mere fact that certain advantages are found where the turbo blower is used, which were not found before its introduction, is due solely to the type of blower introduced, or whether they would not have been obtained equally well with any other type of good modern blower.

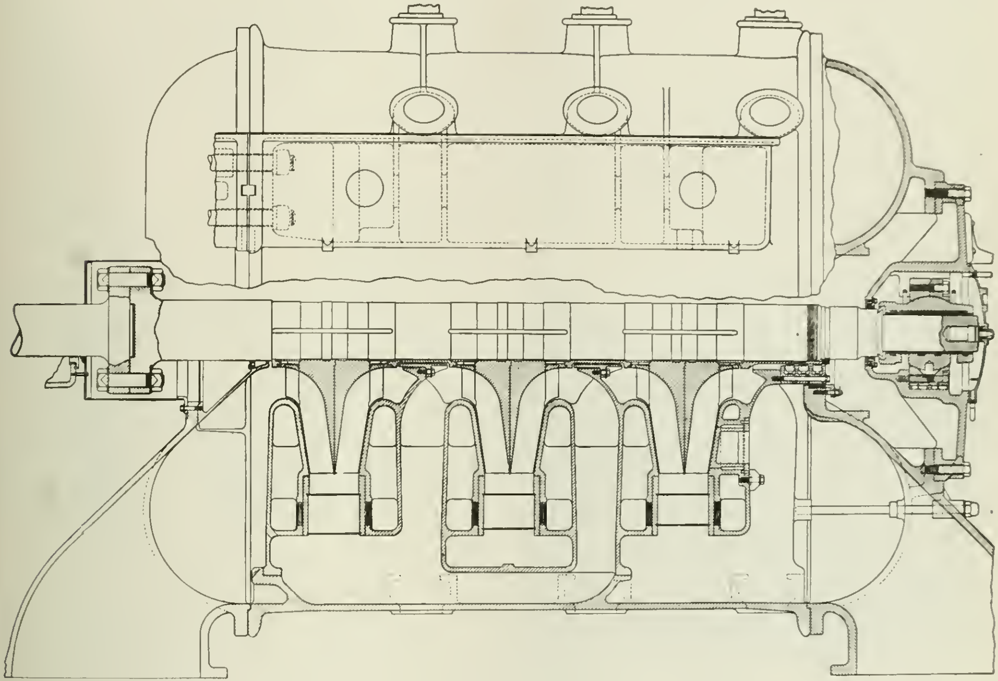


FIG. 35—THREE-STAGE GENERAL ELECTRIC TURBO BLOWER PARTLY IN SECTIONS

Much is claimed also for the accuracy of calibration of the air-measuring apparatus of these machines, and in a paper by Mr. S. G. Valentine, read at the February, 1914, meeting of the American Institute of Mining Engineers, and published in the *Transactions* for that year, he gives the results of his experience in the use of one of these blowers on a furnace which bear upon this point. Among other data he states that only 41 cu. ft. of air were required to burn a pound of coke based on the calibration of the air-measuring apparatus of the turbo blower. We shall subsequently see that about 63 ft. are required theoretically for this purpose without any loss by leakage, not only in the engine but around the stoves, the tuyere and elsewhere, and if only 41 ft. are used then one-third of all the fuel charged is being dissolved by direct deduction in the upper regions of the furnace and never reaches the tuyeres at all.

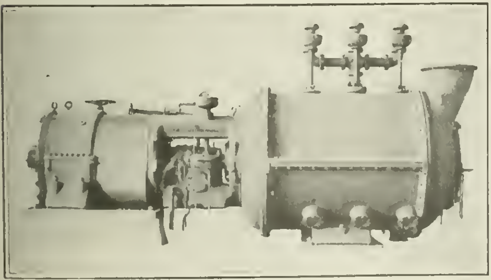


FIG. 36—CENTRIFUGAL COMPRESSOR RATED TYPE T—3—25,000—15/30—3000 3800 DRIVEN BY A 2000 3400 CONDENSING CURTIS STEAM TURBINE

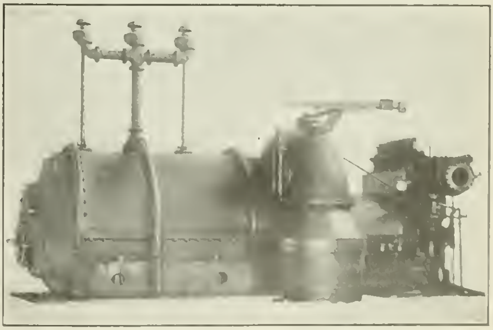


FIG. 37—TYPE T—3—35,000—15 30—2500 3250 F CENTRIFUGAL COMPRESSOR DIRECT CONNECTED TO 2900-H.P. CURTIS STEAM TURBINE

This hypothesis does not agree with the relative low fuel consumption reported by Mr. Valentine of about 2150 lb. of coke on an ore mixture consisting largely of magnetite which required a large amount of heat in the hearth, and, in fact, Mr. Valentine admits that his figures, based on the analysis of the top gases and carbon burned, differ from the calibration figures of the turbo blower by about 10 per cent.

I have information concerning practice in which the solution loss is likely to be much higher than it is in Mr. Valentine's practice, and in spite of this the actual quantity of wind per pound of coke figured from the analysis of the top gases and the actual coke burned at a number of furnaces for a long period of time was over 51 cu. ft., or more than 25 per cent in excess of that shown by Mr. Valentine's figures.

I have recently been advised by Prof. J. W. Richards, of Lehigh University, that he has gone over the data given by Mr. Valentine by two different methods and that both show clearly that the actual air delivered by this turbo blower must have been 15 per cent greater than the calibration of the machine indicated, and making this correction it would seem that the correct displacement of the turbo only corresponds to about 3 per cent more air delivered than the piston displacement of the antiquated engines it replaced. This is probably not altogether correct but it does seem to be established by these data that the calibration of this turbo is decidedly incorrect and that any claims made for superior economy based on these results are a structure on a foundation of sand which will not fare well at the hands of discriminating criticism.

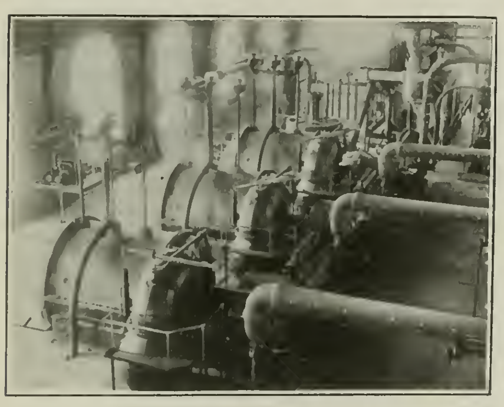


FIG. 38—THREE TYPE T—3—40,000—15/30—2500/3250 R.P.M. FAIR COMPRESSORS DRIVEN BY 2900/5200-H.P. CURTIS STEAM TURBINES INSTALLED AT IROQUOIS IRON COMPANY, CHICAGO, ILL., FOR BLOWING 500-TON BLAST FURNACES

Considering the extremely elusive nature of air and the possibility of error in measurements of its velocity, due to the fact that this velocity at points quite close together may vary very widely, I am led to the conclusion that the calibration of these machines is not yet on a basis of such complete reliability as their manufacturers seem to believe.

The subject as a whole is a new one, and the number of those who have had an opportunity to handle turbo blowers is very limited, the writer not being among the number. It is therefore not possible at this time to say the last word on this or many other details of this subject.

### The Disadvantages of the Turbo Blower

#### I. PULSATION OF DISCHARGE

Under certain conditions of operation at considerably less than the rated capacity of these machines, they are liable to a very disagreeable pulsation of the discharge, the theory of which I do not completely understand, though I believe it has been worked out mathematically. It seems to be due, however, to the fact that the volume is too small to maintain the delivery velocity necessary to overcome the pressure over the whole area of discharge, continuously, and the discharge therefore breaks and a backflow from the discharge pipe into the turbine casing takes place at short intervals, producing this pulsation. It is claimed to be overcome in the later types of these engines by the introduction of a butterfly throttle valve in the inlet pipe above the diaphragh.

#### II. INEFFICIENCY

The efficiency claimed for these machines by their builders under best conditions is 70 per cent, and of course this falls off on both sides of the maximum along the characteristic curve of practically all centrifugal pumping machinery.

The diagram factor of the air card from a well-designed blowing engine as a whole is about 95 per cent, and the mechanical efficiency of the engine as a whole, as I have previously stated, should be about 92 per cent. By diagram factor is meant the ratio of the actual diagram produced by a given engine under a given discharge of pressure to the theoretical indicator card with an adiabatic compression for the same pressure. The product of these two is about 87½ per cent, the difference between this and 70, or 25 per cent, is the handicap which the turbo blower must overcome to equal the performance of the reciprocating blowing engine.

Turbines have been brought to a very high state of perfection, particularly in very large units, such as are used in electric generating stations. But it may reasonably be doubted whether a turbine of, say, 3000 hp, with an efficiency of 70 per cent in the blower end, which would deliver 2100 air-hp, can do 25 per cent better in steam consumption than a steam engine properly designed and running with the conditions of boiler pressure, superheat, and vacuum, which are admittedly indispensable to the economy of the turbine.

If it be impossible for the turbine to do 25 per cent better than the reciprocating engine under these conditions than obviously the superior efficiency of the turbine will not offset the low efficiency of the blowing end, and the turbo blower as a whole will be a less economical unit than the reciprocating steam engine.

The steam expert of one large and extremely well-managed company has publicly expressed a doubt as to whether the turbo blower could get along with as little steam as the reciprocating engine, his company having both reciprocating engines and a turbo blower in the same building and operating under identically the same conditions.

#### III. FAILURES

There have been several wrecks of turbo blowers in this country, but these apparently have been due to defects in the design of new and larger units than had before been attempted, rather than to any inherent defect in the principles involved. This we have long since learned is the price which must be paid in the development of new equipment, and must therefore not militate unduly against the turbo. At the same time, it cannot be denied that turbines in other service have more than once "gone through themselves," to use the expressive phrase of the operator, with consequences so disastrous as to leave little of the structure of any value, even for repair purposes. Before the turbo blower can establish the supremacy towards which its builders are casting their eyes, it must establish a high degree of immunity from accidents, and also an economy not only eclipsing that of the best reciprocating steam engines, but rivaling that of the gas engine, which increasingly, as time goes on, must become a powerful competitor in blowing machinery.

### The Condenser

The auxiliaries of the steam plant at a blast furnace do not differ from those of any other steam plant of similar size and character, and for that reason it is not necessary to discuss most of them here, but the condenser is important enough to deserve some attention.

These for steam engines are of two types, the direct contact or jet condenser, and the surface condenser. Surface condensers are high in first cost and having an enormous number of packed joints are difficult of maintenance for continuous operation. Moreover, the water available at blast furnaces is not always of such character as to enable them to be kept as clean as they should be for best results, and when foul they soon lose their efficiency and the vacuum drops. For this reason when reciprocating blowing engines are used the elevated syphon condenser, working on the counter-current principle, and with positive means for removing the air, is very generally preferred.

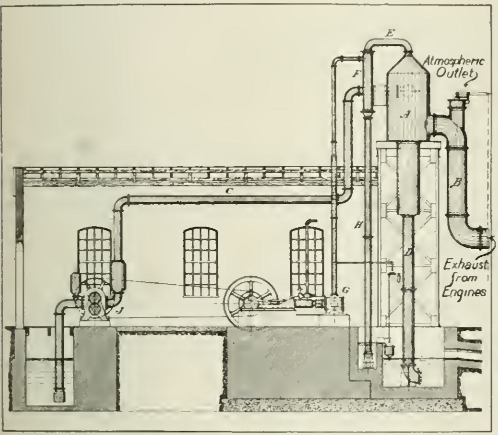


FIG. 39—WEISS CONDENSER

The first of these brought into use was the Weiss, introduced by the Southwark Machine Company, shown by Fig. 39. This is of the elevated type with a vertical tail pipe about 35 ft. long, long enough, in other words, to carry out the condensing water and water of condensation without pumping, against any vacuum which the condenser may produce. The air is taken off from the condenser by a dry-air pump, *G* in the illustration, the condenser being designed to discharge the air after it has received the maximum cooling possible, so as to make its density at this low pressure as high as possible and enable the air pump to handle it to the best advantage. The air pump engine drives by belt or gear drive a rotary pump, known as the Bibus pump, which supplies the water for the condenser. The Bibus pump is used on account of its high efficiency, but owing to its gearing, etc., this pump is not as well adapted to run submerged as is a plain centrifugal pump, and as condenser pumps in the nature of things are extremely likely to be submerged from time to time, I personally prefer the simpler if somewhat less efficient centrifugal machine which can run submerged indefinitely.

Several condensers of the same general style as the Weiss are now on the market, of which one of the best and most favorably known is the Helander, designed by Mr. A. H. Helander, formerly chief engineer of the Mesta Machine Company, now vice-president of the William Tod Company, of which a photograph is shown in Fig. 40. This condenser dispenses with the supporting tower used by the Weiss, the tail pipe of the condenser itself being made strong and stiff enough to support it. The air is taken off at the high point of the condenser body, as in the Weiss, different types of apparatus being used to pump it out.

In some installations a steam jet or modified exhauster has been used whose steam economy is not very much lower than that of a mechanical pump, and which is low in first cost, and completely eliminates moving parts. In other cases a crank and flywheel vacuum pump is used as in the Weiss. Water is generally supplied by a centrifugal pump driven either by a motor or by a small direct-connected steam turbine.

In blowing engine plants one condenser is generally installed for several engines, and this system has much to commend it, at the same time if steam for many units is to be condensed, the distance through which the exhaust has to be carried to the condenser becomes great and the piping large and expensive, while the vacuum realized on the further engine is probably never as good by an appreciable amount as in the nearer engines, so that this system must not be carried to extremes, especially as the high cost of the exhaust piping in a large installation would go far to pay for additional condensers. Neither must it be forgotten that several units of this kind have the advantage of greater flexibility and more freedom from general interruption than a single large unit.

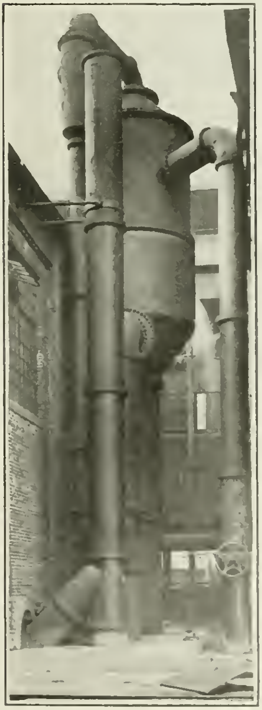


FIG. 40—MESTA HELANDER BAROMETRIC CONDENSER

For turbines the barometric condenser is sometimes used but to get the best results these machines require vacua which measured as absolute pressures are only from a half to a third of those used with steam engines, therefore it is highly desirable to have the exhaust connection extremely short and very large, so as to avoid both friction losses and leaks. For these reasons the condenser for the turbine is in the best practice placed immediately beneath it and in some cases forms the base upon which the turbine rests. For this service either some sort of jet condenser with water discharge as well as dry-air pumps, or a surface condenser is used. The latter is particularly desirable with turbines for the reason that their exhaust contains no oil and may be used for boiler feed without treatment, and for the high vacua desired in this service they have the advantage of not introducing any air dissolved in the condensing water, which is an important factor under these conditions.

As a result of these considerations new types of jet condensers have been invented and new designs of surface condensers brought out so that condensers as a whole have received a vast development in recent years. In relation to blowing power for furnaces, however, these conditions are not sufficiently important to justify more extensive treatment here.

### Combination of Turbine and Reciprocating Engine

There is an application of the turbo blower to blowing engines of which no actual installation has as yet been made, but the possibilities of which have been figured out on the basis of actual practice, and specifications prepared for such an installation. One is likely to be made before this work appears in print.

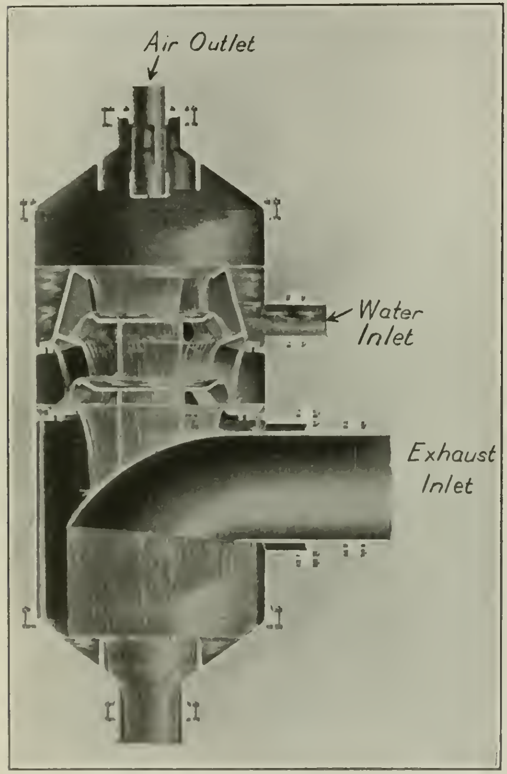


FIG. 41—VERTICAL CROSS-SECTION OF HELANDER CONDENSER VESSEL

This is a combination of the turbo blower driven by a low-pressure turbine, with existing blowing engines. The turbo blower is not designed to blow the full pressure required for the furnace, but only to do about one-half the work of compression, supplying the air under this partial pressure to the air cylinders on the existing blowing engines.

The advantage of this combination is that the turbine is a more efficient motor for pressures below atmospheric than the steam engine, particularly where high vacua are obtainable, and the turbo blower, while not more economical for low pressure than a good piston blower, is relatively more economical for low pressures of 6 or 7 lb. than it is for pressures of 15 lb. and upward, not because the turbo itself has a higher efficiency at the lower pressures, but because the friction of the large cylinders required for reciprocating blowers, unless they are most carefully designed, reduces the mechanical efficiency of that type of machine at low pressures, so that it is doubtful whether they are as economical below 6 lb. as are rotary blowers or perhaps turbo blowers, therefore the rotary unit as a whole is more economical for very low pressures than a reciprocating one. It is also much lower in first cost, and by combining the two types of machines and using each for the range of pressures for which it is best adapted, we obtain the highest efficiency with the lowest first cost. This is particularly true where existing installations are either uneconomical, unable to blow the pressure required, or unable to furnish the volume required.

By putting a turbine and condenser on the exhaust of a non-condensing engine we can recover a horsepower for about 30 to 35 lb. of steam, depending on the vacuum available. This power applied to a turbo will compress the quantity of air required to a pressure in ordinary cases of 5 to 7 lb. This increases the density of the air and therefore increases the capacity of the air cylinders of the reciprocating engines, and also obviously raises the pressure to which they can compress the air by at least the amount of this precompression.

The turbo blower will compress air to a pressure of $6\frac{1}{2}$ or 7 lb. in a single stage; therefore, in ordinary cases only a single-stage unit will be required in applications under this system.

Both the reciprocating engine and the turbo blower labor under certain disadvantages when used singly which are eliminated when they are used in combination, thus the turbo blower alone must have stages enough to blow the maximum power required, for instance, 30 lb., even though 15 only will be required 99 per cent of the time. Similarly the air cylinder of the reciprocating engine must be large enough for the maximum volume of air to be handled, even though this be required only occasionally. The turbo blower, on the other hand, can supply any increase in quantity of air desired within reason, without any change in its construction, while the blowing engine can compress to any pressure within reason without any change in its construction.

By combining these two units we obtain the volume capacity of the one and the pressure capacity of the other without the need of excessive size in one case, or multiple stages in the other. This arrangement has also the great advantage of retaining the metering effect of the piston of reciprocating engines, which is certainly more positive than the systems of volume governing so far applied to the turbo blower.

In the combined unit the question of governing the turbo practically takes care of itself, since the quantity of steam exhausted by the reciprocating engine controls the speed of the turbo, and this steam must depend upon the volume of air blown and the pressure to which it is raised. If the blast pressure required increases the tendency of the reciprocating engine is to slow down slightly and so slightly to decrease its discharge while the increased quantity of steam which it exhausts tends to increase the speed of the turbine and so to increase the pressure at which the turbo blower discharges, thus making up by an increase in density for any decrease in displacement of the reciprocating engine.

In the actual case for which specifications were prepared, there were three standard long cross-head blowing engines, two with good steam cylinders, the other with a poor steam cylinder, all non-condensing. The owners had obtained bids on a single low-pressure unit to take the exhaust from one of these engines and run condensing, letting one of the high-pressure engines run condensing with the other standing as a spare.

It was easy to show that on the basis of the guaranteed figures of the turbo blower manufacturers a single turbo blower could be installed which would supply the two good existing high-pressure engines with air compressed to 6½ lb., and this increase in density, with a slight and entirely permissible increase in speed, would have made the weight of air discharged by these engines the same as that now discharged by all three. The exhaust from both of these would have gone into the low-pressure turbine, and from that into the condenser, and would have been sufficient with any ordinary vacuum to drive the turbo blower at a speed which would enable it to supply precompressed air to both reciprocating engines. The third engine would have stood as a spare. The air cylinder heads of the blowing engines would have required to be closed in so that they could receive this air under pressure. A large inward-opening check was to be provided in the pipe carrying the precompressed air so that if anything happened to the turbo blower it could instantly be shut down and the reciprocating engines would then get their air supply from the atmosphere. This would have given the furnace two-thirds wind until the third engine could be started up, which would be only a matter of a few minutes. Finally it was shown that this equipment could be installed complete for a considerably smaller sum than would be required for the low-pressure unit, and that its steam consumption would be smaller than that on the other plan by several thousand pounds per hour.

This possible installation is set forth here because of the advantages which I believe it to have for such cases. It may also be said that the installation above described, while not installed as yet, was not rejected by the owners on account of any defect in the system, but only because they decided not to install additional blowing power at that time.

### The Gas-Driven Blowing Engine

It is now more than half a century ago that Otto first built internal combustion engines using the four-stroke cycle, and the economy of these engines was early recognized as being far superior to that of the steam engine in thermal units required. Before the days of the universal use of gasoline, gas was the only fuel used in such engines, and the difficulty of making suitable producer gas for them stood in the way of their earlier introduction.

In the case, however, of blowing engines for blast furnaces, which are in one sense only gigantic gas producers, the advantages of using the gas they supply directly in the engine cylinders are obvious. The first suggestion to carry out this plan was made in 1876 by Mr. Frank Firmstone, then manager of the Glendon Iron Works, to Mr. P. L. Weimer, of Lebanon, an engine builder of some note, but nothing was done in the way of carrying it out for nearly twenty years, when in 1895 Mr. B. H. Thwaites in England installed a small gas engine and operated it continuously for a considerable period on blast-furnace gas.

The idea was then taken up by German and Belgian engineers and to them is due the credit for overcoming the enormous technical, mechanical and financial difficulties involved in carying this simple scheme into successful practice.

It was only after engines of this type had reached a high state of development in Europe that they were introduced into this country, a circumstance which has caused much shame to some good Americans, but I believe does not reflect as much discredit upon this country as has frequently been claimed, on account of differences in conditions unnoticed by casual observers. These differences are financial and industrial rather than technical, and consist in the fact that in Europe capital can earn only a relatively small rate of interest and labor only a small rate of wages compared with what both command in this country, while raw materials are scarce and dear in Europe and have in the past been ridiculously cheap in this country, particularly coal.

The saving to be made must be bought, as we shall presently see, at the price of enormous expenditures in capital and in high-priced skilled labor, while its value could only be measured in terms of the saving in coal, one of our cheapest commodities.

When these technical savings were reduced by the amount of the high labor cost required to make them, the interest which the balance would pay on the capital involved was often less than could be earned by that capital in addition to the producing capacity of the plant otherwise.

It is true that this view of the subject involves the use of coal which might be saved for future generations by the other system, but this is a subject to follow which would take us far beyond the proper boundaries of this work and I shall not attempt to analyze it further than to suggest that, admitting the value of the "conservation" idea, it is proper to ask whether the saving of money, which represents value already created, may not be as justifiable as the saving of raw material which only has potential value.

Or to put the matter in different form, if the owner of a plant can make more interest on the capital invested by using more raw material than is theoretically necessary, who is to compensate him for the loss he makes by following the opposite course?

On the other hand, this policy is capable of great abuse, and Americans, as a nation, have had in the past and to some extent have even yet a tendency to prodigality and to ignore savings of various kinds which they might make, more through mental inertia than through any more worthy motive.

It may be admitted that the policy of conserving capital at the expense of raw material has often been carried too far, and the gas engine may be such a case. I shall give at the end of this chapter an outline of the method by which this question may be settled on its merits in each individual case.

The conditions to be met, and the difficulties to be overcome in making the gas-blowing engine a success may be briefly stated as follows:

First: Blast-furnace gas as it comes from the furnace contains a vast quantity of fine and exceedingly abrasive dust which must be completely removed before it is introduced in the cylinders of the engine or the latter will soon be destroyed by wear.

Second: The gas engine is a prime mover with little or no overload capacity, and with an efficiency which diminishes very rapidly as its load drops off. This is the opposite to the condition in the case of the steam engine, which has a very large overload capacity, and which maintains its economy well at loads very much smaller as well as much larger than its rated load. Therefore, when the blast pressure required by the furnace changes, the steam engine has no difficulty whatever in accommodating itself to the change, but the gas engine must either work at the disadvantage of an uneconomical light load normally, in order to be able to carry the heavier pressures when they arise, or else it must have special devices to enable it to compress less air when a high pressure is required, at the same time maintaining its speed and power.

Third: The gas engine when it began to be developed for use for blast-furnace gas was very largely a single-cylinder, single-acting engine, which, with the four-stroke cycle, meant that it received but one working stroke in two revolutions. The reason for this limitation was that it was considered almost impossible to operate piston rods with their accompanying glands at the high pressures and high temperatures involved in this type of engine.

Fourth: Owing to the intermittent and rather complex nature of their cycle these engines were in the early days freakish, unreliable, uncertain and difficult to operate to a degree which in the opinion of many American engineers debarred them from use.

Fifth: Owing to the operating difficulties just mentioned, and to the high repairs which went with them, the operating and maintenance cost was very high.

Sixth: The first cost of these engines, both for the engine proper, for foundation and for house, was and is even yet enormous, and as this first cost must be amortized at a relatively heavy rate on account of the rapid obsolescence, and somewhat rapid deterioration of these engines, the fixed charges on them were very high.

Coming now to the solution of these problems and difficulties, the result desired has been achieved in each case by the same formula. A vast amount of technical work of the highest order, the endurance of a vast number of operating difficulties which resulted in deficient blast supply for the furnaces at frequent intervals of uncertain duration, and made the managers regret the day that the gas engine was born, but which led eventually to methods whereby these difficulties might be avoided or overcome, an enormous number of experiments, many of which in the nature of things were unsuccessful, and the expenditure of great sums of money for development.

### THE CLEANING OF THE GAS

Great harm was done to the gas engine in its early days by the premature publication of the results of an experiment in trying gas which had not been thoroughly cleaned. It was claimed that only primary cleaning was necessary, and that the fine dust left by this simply went into the cylinder and came out again without doing any harm. A few months longer trial, however, soon showed that while most of the dust followed this course, enough of it adhered to the oily surfaces of the cylinder and piston rod to cause the rapid destruction of those parts, and it was then realized, once for all, that the gas must be cleaned, not only in primary washers, but must be scrubbed until the amount of dirt left in it was a negligible quantity. It is said that in present practice the gas passing into these cylinders is cleaner and more free of dust than the air we breathe.

This is not the place at which to deal with the question of gas cleaning, but it seems to be a fact that a positive and reliable solution of this problem, which could be guaranteed, was first obtained by the German engineer Theisen, and after the invention of his apparatus the development of gas-driven engines was much more rapid than before.

### ADAPTING THE ENGINE TO VARIABLE LOADS

In Germany the method has largely been adopted of holding open the inlet valve during a greater or less portion of the compression stroke, and so, in fact, cutting down the capacity of the air cylinder when higher pressures were required than those for which the engine was designed. But in this country this plan seems not to have found favor, and in general the gas cylinders have been made large enough to blow the maximum pressure normally required, any change from this being met by adjustment of quantity or quality of gas mixture and enduring the consequent loss of efficiency.

This is for the reason that when a furnace gets "tight" and the pressure goes up, it is frequently, if not generally an indication that it needs more air and if this be not supplied a scaffold is liable to form causing weeks or months of trouble.

Therefore the plan of reducing the volume of the blast in order to attain the increased pressure needed does not commend itself to furnace men; it is good for the engine, but likely to be very bad for the furnace.

### ADAPTING THE ENGINES TO RUN DOUBLE ACTING WITH TANDEM CYLINDERS

The difficulties which prevented this development in the early days were those which came from the intense heat acquired by any surface of small curvature, such as a piston rod, unless it was water-cooled. The head and barrel of gas-engine cylinders have been water-cooled since the very beginning, but on account of the mechanical difficulties the early engines were made single acting and their pistons were not so cooled but made long and allowed to get their cooling effect from the barrel of the cylinder and from the air in the crank chamber. This, with the plain flat piston heads without projections, enabled them to run without getting so hot as to cause premature explosions.

When it became necessary to obtain more working strokes per cycle the trunk piston was discarded and the regular piston and piston rods of the standard engine substituted, except that these were both made hollow and water-cooled by flexible or trombone connections to the cross-head or to the rear end of the piston rod. This having been brought into successful practice, the next step was to add a tandem cylinder and run the piston rod through to its piston, and with the experience based on the previous work this was soon brought into successful operation.

In the four-stroke cycle gas engine only one stroke of four is a working stroke instead of every one, as in the steam engine. Therefore by putting two double-acting cylinders tandem and having their working strokes alternate one with another two working strokes per revolution were obtained as in the steam engine. This resulted in an enormous reduction of the irregularities of power development and turning moment, from which the early gas engine suffered.

### ELIMINATION OF DIFFICULTIES AND UNCERTAINTIES OF OPERATION

This has been even more than the others a matter of patience and detailed attention to small and apparently unimportant points. The ignition system which was at one time under electrical control and with only one igniter per cylinder head, has now been made entirely mechanical with two or more independent igniters per cylinder end, so that one will ignite the charge if the other fails. Pilot lights on these igniters show whether they are working or not and enable difficulties to be cured before shut downs from the failure of both can occur.

The type of design which has the strength to resist the heavy internal pressures due to the gas explosion, and at the same time is so free from inequalities as to avoid heating strains, and the cracking and failing of cylinder heads and pistons which come from that cause, has gradually been evolved. The system for supplying water for cooling the pistons and piston rods has been developed so that the formation of air and steam pockets is prevented, and the overheating and premature explosion and cracking which arose from those causes are thereby avoided.

In this country the center crank construction has been discarded in favor of the over-hung single crank because the latter requires only one bearing, and definite knowledge of its adjustment and condition and of the stresses upon it are obtainable, whereas when the center crank is used, two main bearings are required, and the rocking stresses which may be developed by the maladjustment of one of them are enormous and entirely impossible to determine.

The valves of the engines have been put in convenient and accessible locations so that they can be readily removed for examination or replacement, and at the same time so that dirt will not lodge upon their seats, with the consequent destruction of the latter.

All of these details and many more have been subjected to the most rigid, patient, and penetrating investigation, so that the causes which led to these difficulties have either been avoided altogether or their results have been overcome to the best advantage.

### EXPENSE OF OPERATING AND MAINTENANCE

The thorough cleaning of the gas eliminated at one stroke a great number of the operating difficulties of the gas engine, while hand in hand with this went the knowledge obtained by both designers and operators from the patient investigation of and improvement of details described under the fourth heading so that great plants of gas engines may now be seen running apparently with but little more attention and no more repairs than would be required by an equal number of steam engines of similar power.

### THE REDUCTION OF THE GAS ENGINE TO STANDARD PRACTICE

The gradual elimination of the experimental work required in the early days of its development, and the fact that a number of reliable and experienced engine builders have undertaken its manufacture under competitive conditions, have all tended to reduce the first cost of these engines, while the standardization of designs and better adaptation of the means to the end sought have lowered their rate of obsolescence so that the amortization period is longer and this in conjunction with the lower first cost has greatly reduced the overhead charges.

## Type of Gas Engines

Owing to the length necessary on account of their tandem cylinders and to the excessive stresses to which they are liable from the nature of their working cycle, gas engines in large sizes for the iron and steel industries have never been built except as horizontals, therefore the number of types is very much more limited than is the case with steam blowing engines.

The first installation of gas blowing engines on a large scale in this country was that of the Lackawanna Steel Company at Buffalo, which was started about 1903-04, and has been the bone of many bitter arguments pro and con on the whole gas engine situation and on the particular type of engine installed. These are two-stroke cycle engines built under the Koerting patents.

They have a single double-acting cylinder on each side and every alternate stroke is a working stroke exactly as in the steam engine, their gas and air being supplied them by large pumps driven by cranks in the ends of the main shaft, one of which supplies the gas, the other the air, not only for combustion, but also for scavenging the cylinder of the burnt gases from the last stroke. This is done by a "plug" of air which is driven through the cylinder behind the burnt gases and in front of the fresh charge and to a great extent prevents the mixing of these, which would greatly reduce the efficiency.

No exhaust valve is used. The piston uncovers an annular port in the cylinder near the end of its stroke and the burnt gases and plug of scavenging air escape through this while it is uncovered. During the latter part of this interval the fresh charge is introduced into the rear end of the cylinder, but is prevented from escaping by the air plug.

This engine then avoids the necessity of having two cylinders to make each stroke a working stroke and avoids the exhaust valves of the four-stroke cycle, but does so at the price of two large crank-driven pumps which have to raise the charge to higher pressures to force it into the cylinder than is necessary in the four-stroke cycle in addition to which the air required for scavenging only, must be handled and compressed. These engines after more than ten years of continuous service are still in regular operation and, although steam-blowing engines are installed, they are held in reserve and the gas engines run by preference not only of the mechanical department, but also of the furnace manager, because they are not only more economical but require less attention and repairs than the steam engines.

The gas-cleaning installation at this plant is almost rudimentary as compared with more modern ones and the resulting gas much less clean, yet these engines are operating successfully with the original cylinders in some cases without even being bored out and lined with some of the original piston rods and almost all the original pistons.

These engines have horizontal gas cylinders and vertical air cylinders concerning which construction no more need be said than was said concerning the steam engine of that type, except that the high speed and great inertia of the reciprocating parts of the gas engine makes it even more unnecessary than in the steam engine, and it has not so far as I know been used in any other large installations of gas blowing engines in America.

Judged by the test of time and service this installation must be judged as great a success as an initial installation of any kind ever is. It was described in much detail by Mr. E. P. Coleman in Vol. XXXII of the *Transactions* of the American Society of Mechanical Engineers in which excellent article the statement is made that these engines require about 18,500 B.t.u. per indicated horse-power in the air cylinders, an efficiency of 13.7 per cent.

Recent types of four-cycle engines at three-quarter load give about 22 per cent efficiency at the shaft and reducing this by 10 per cent we get 20 per cent as the efficiency based on the indicated horse-power in the air cylinder or nearly one-half more than of the Koerting engines, so the reason for the exclusive use of the four-cycle type is not far to seek. At the same time these four-cycle engines represent a much more recent state of development than do the Lackawanna engines and it is claimed that the later examples of this Koerting type in Eprope give far better results than do the earlier ones. Still it must be acknowledged that while many attempts have been made to improve the economy of the two-cycle engines for all uses and in all sizes none of these attempts have ever succeeded in putting it in the same class for economy as the four-cycle, and it may now probably be said with safety that there are fundamental obstacles to success in this endeavor which will never be overcome.

Fig. 42 shows a gas blowing engine built by the William Tod Company with twin tandem gas cylinders on one side of the crankshaft and a blowing cylinder on the other side, driven by stretcher rods as described for the inside crank steam engine. This construction is no shorter than that of a straight tandem engine, and as the piston rods pass through the cylinder heads, and are supported by slides outside them in all cases, I do not fully understand the advantages of this construction, but it is in extensive use and seems to give good satisfaction.

Fig. 43 shows a similar design of engine built by the Allis-Chalmers Company, and Fig. 44 shows one of the largest installations of gas blowing engines in this country, also built by the Allis-Chalmers Company.

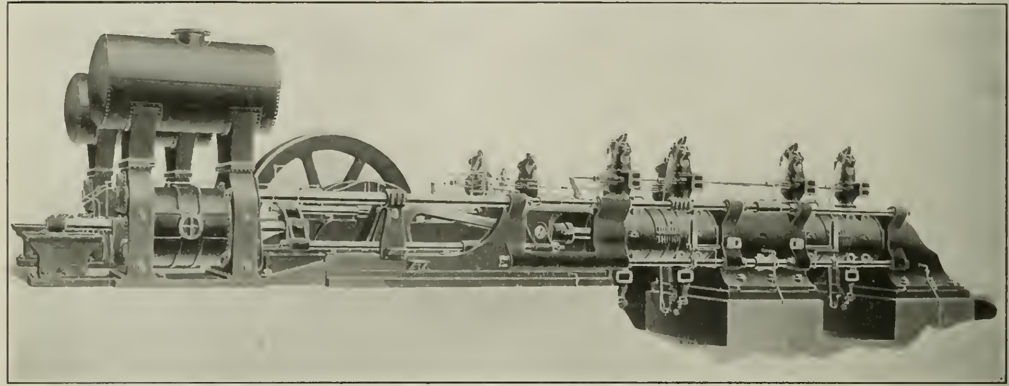


FIG. 42—42 AND 80 X 60 GAS BLOWING ENGINE

Fig. 45 shows in outline a straight tandem gas blowing engine built by the Mesta Machine Company with the crankshaft at one end and the blowing cylinder at the other, a design which I prefer to the inside crank type.

All these engines are of the four-stroke cycle, double-acting, double-tandem type with admission valves and exhaust valves all in the central vertical plane to give maximum accessibility without the necessity of removing cylinder heads and avoid the formation of pockets in the cylinder heads.

The details of the designs differ but not very much more than the details of steam engines.

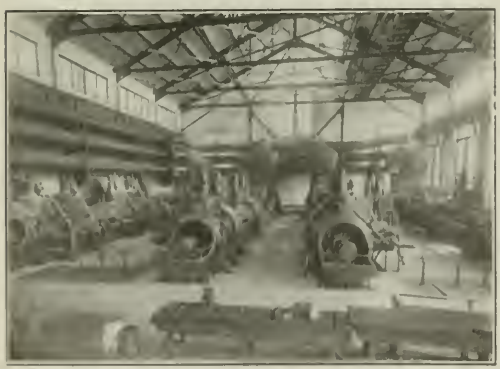


FIG. 43—ALLIS-CHALMERS 44 X 60 TWIN TANDEM GAS ENGINE WITH 60 X 60 AIR CYLINDERS

The air cylinders do not differ from those of steam engines except that the speeds at which they are required to run average higher and the valves must be designed to meet this condition.

### THE SPEEDS OF GAS ENGINES

It is a remarkable fact that a number of builders of blowing engines should balk at the idea of running a steam-driven blowing engine more than 40 revolutions, yet design and build regularly gas engines of the same stroke to run from 70 to 85 revolutions, and the situation is made the more remarkable by the fact that the reciprocating parts of the gas engine are about 50 per cent heavier than those of the steam blowing engine of similar capacity. This, with their high rotative speeds, double those of many steam engines, makes the inertia about six times as great as it is in the steam engine. The set of indicator cards from a gas-driven blowing engine, obtained through the kindness of the William Tod Company, of Youngstown, and shown by Figs. 46, 47 and 48, are from a 42 and 80 by 60 gas engine with a rated speed of 65 revolutions, with reciprocating parts weighing 94,500 lb. for each side.

From these I have prepared the net pressure diagrams for a pair of gas cylinders and the corresponding air cylinder, shown in Fig. 49. These have been reduced into a combined net pressure diagram of both sets of cylinders, shown in Fig. 50, on which is drawn the line of inertia effect at 65 revolutions and in dotted lines the inertia effect at 60 revolutions.

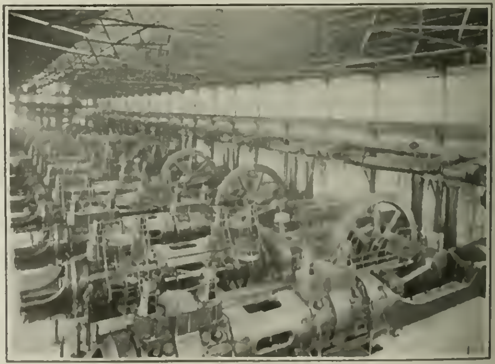


FIG. 44—ROW OF EIGHT ALLIS-CHALMERS GAS BLOWING ENGINES

In Fig. 51 is shown the resultant of these combined air, gas, and inertia diagrams at 65 revolutions. It will be seen that the equalization of power developed and power absorbed by this means is very good, but that the speed is, in this case, if anything a little too high, and that a better equalization would be obtained at 60 revolutions.

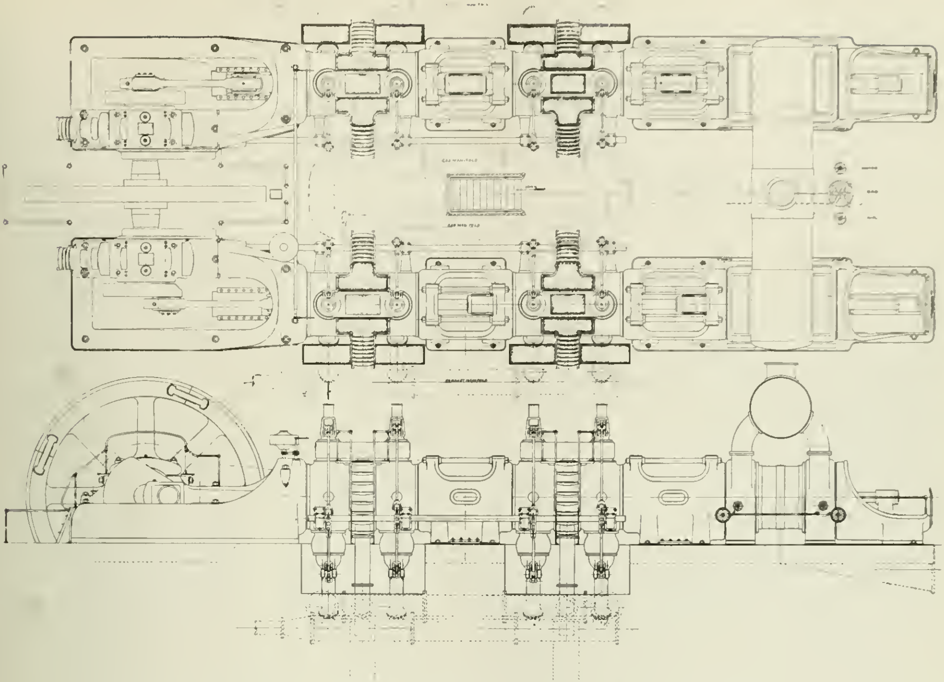
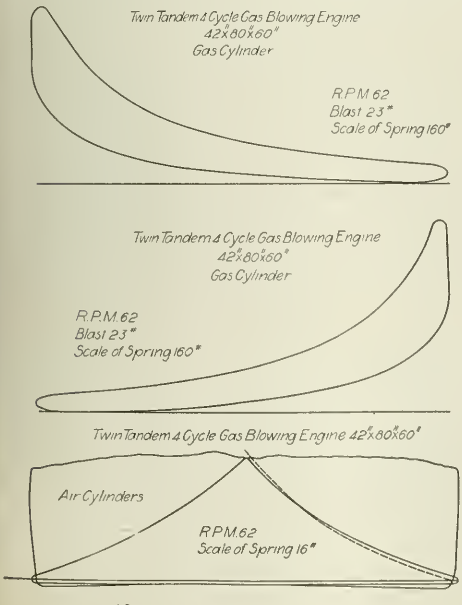


FIG. 45—MESTA GAS BLOWING ENGINE TWIN TANDEM ARRANGEMENTS

The stroke of this engine is 5 ft., that of the horizontal cross-compound, of which inertia and combined diagrams were presented earlier, was 6 ft., only 20 per cent more. It seems remarkable that this engine should be run at a speed of 65 revolutions, while the rated speed of the steam engine was only 40 revolutions, although it would obviously do better work if its detail proportions were right, at 55 revolutions, than it would at 40, with an increase in output of practically 40 per cent and without any countervail disadvantage.

I think the explanation is that the gas engine sim-



FIGS. 46 TO 48—TOD GAS ENGINE CARDS

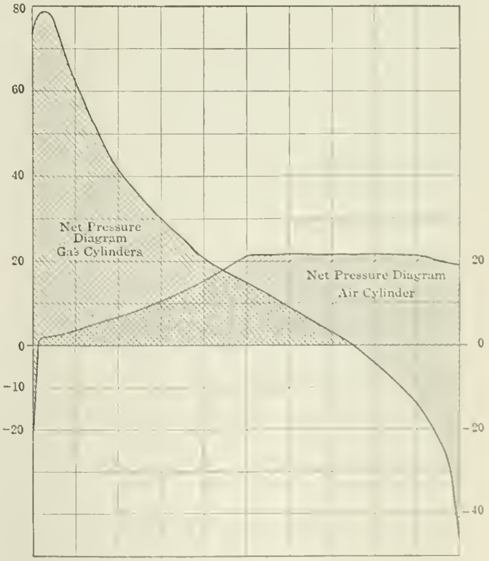


FIG. 49—NET PRESSURE DIAGRAM

ply will not run properly at low speeds on account of the frightful variations in pressure, and the reverses of stress consequent on them, and engine builders have been compelled to run them at a proper speed whether they would or not; while in the case of the steam engine the reversals of stress were so much less severe that the engine could endure them without the equalizing influence of the inertia effect and the obvious advantages of higher speed have been ignored because the engine could make out without them.

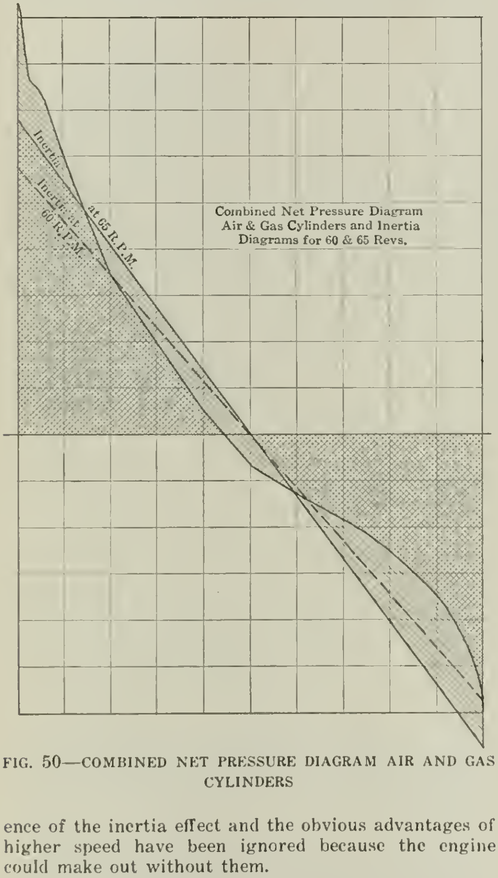


FIG. 50—COMBINED NET PRESSURE DIAGRAM AIR AND GAS CYLINDERS

It may be of interest to point out here also the "spike" of pressure due to the reëxpansion of the air in the clearance space which increases the total pressure on the running parts of the engine 15 or 20 per cent above what it should be at the beginning of the stroke.

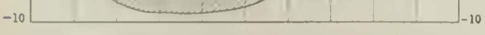


FIG. 51—COMBINED DIAGRAM AIR, GAS AND INERTIA

It would seem that by delaying the ignition very slightly the explosion line of the diagram could be made to slope forward by a very small amount so as to offset the pressure from the reëxpansion of the clearance air and that this would not lessen the area of the diagram by an appreciable amount, while it would reduce the maximum stress on the whole engine to an important extent.

### The Choice of a Type of Blowing Engine

From what has been said it will be seen that we have the choice of three very separate and distinct types of blowing engines. It would be very desirable to make a definite pronouncement as to the superiority of one of these types, but it is not possible to do this for two reasons. First, the whole matter is in a state of active controversy at the present time, with the advantage shifting from side to side as one receives additional light upon one or another phase of the situation. Second, there is no definite solution for all cases because the conditions vary greatly.

At a steel plant which has within itself a vast market for power, the power producing capacity of the blast furnace gas must obviously be utilized to the fullest possible extent, so that the purchase of other fuel may be minimized or eliminated, and for this object an investment may be made of from four to eight times the annual net saving, depending upon the conditions and the judgment of the owner.

On the other hand a furnace set down in an isolated location with no other manufacturing or mining operation nearby to supply a market for its power is justified in putting in machinery only so good as will secure for its virtual immunity from the purchase of coal for power purposes, and will give the lowest operating cost exclusive of fuel.

Under these conditions it is obvious that no decision of this question for all cases is possible even if the actual physical data of operation available were complete, and were unanimously admitted by all parties in the controversy, which is by no means the case. The problem must be solved for each case on its own merits, and the lines of this solution may in a general way be laid down. It may be said in advance that recent investigation of this subject with details of actual capital and operating costs of gas engine plants by Messrs. H. J. Freyn, formerly of the Allis Chalmers Company; C. J. Bacon, of the Illinois Steel Company, and Arthur West, of the Bethlehem Steel Company, with data on the steam turbine and turbo blower, submitted by Mr. Richard H. Rice, of the General Electric Company, have indicated that the fuel cost of power production is by no means the only cost, and in many cases is not even the largest item, but that as we pass from the plain and simple types of machinery of old, to the more refined and economical but expensive types of to-day, the fixed charges due to investment rise at a rate which may equal or exceed that at which the value of the fuel saved falls. It is only by considering all these factors that we can arrive at the proper solution in any given case.

### The Outline of the Solution

The first question to be asked and answered is as to the value of power for purposes outside the blast furnace. If no market is at hand or can be created this is obviously zero. If on the other hand there is a market it is obvious that surplus power produced by the furnace must meet the competition of power produced by the cheapest means otherwise available. This will generally be determined in a broad way by the cost of coal at the given locality. Granting the existence of the market for the power at a price so determined, and knowing the quantity of gas to be produced by the given furnace plant we deduct from the former 40 per cent to represent the consumption of the hot blast stoves, and 5 per cent for other auxiliaries around the plant, the remaining 55 per cent is the gross amount which must supply the power required for blowing the furnace and that which is to be sold.

Fairly reliable figures are to be had as to the number of thermal units required per horse power, by each of the different types of prime movers. In the case of the gas engine this can be converted directly into cubic feet of gas required, based on the thermal units per cubic foot of the gas after it is cleaned and cooled and ready for the gas engine cylinders. But in the case of the steam engine and the steam turbine the efficiency of the boiler enters as a factor of much importance. It has been claimed that this may be put as high as 80 per cent, but the best and the most recent data concerning boilers and their operation with blast furnaces gas, indicate that they often reach in practice something less than 60 per cent. This also, however, is capable of investigation and determination for the detailed case in contemplation, and a figure corresponding to the results which may reasonably be expected, must be taken. Due allowance must be made for the steam pressure desired, and particularly for the degree of super-heat desired in the steam, and for the fact that the actual quantity of heat required in proportion to the theoretical is greater as the degree of super-heat rises.

With this information we may figure the number of cubic feet of gas required to produce a horse power in the case of the steam engine and the steam turbine, and in this case the thermal value of the gas per cubic foot in a partly cleaned and warm condition may be taken instead of that for its cold condition, which makes a difference of between 5 and 10 per cent in favor of the steam apparatus. This helps to offset the initial advantage of the gas engine that it only requires about two-thirds as many thermal units per brake-horsepower as do the steam driven motors.

We can now figure the quantity of gas needed to blow the furnace in each case and subtracting this from the total net heat available we obtain the amount available for the development of power to sell. From this we may determine the amount of such power we can produce in each case and its value, from which the operating cost of its production, exclusive of fuel, must be deducted. Against this we must set up the cost of the investment, the proper rate of amortization, and the proper rate of interest on the capital in each case. By comparing these with the net earnings for the power sold in each of the three cases, we can determine which is the best investment, always remembering that the amount of money available, or which can be raised, is more often than not strictly limited, and that the fact that a fine interest can be earned on an extra two or three millions is of little interest or value if the management cannot raise the extra two or three millions. It is also very necessary to remember that the type of motor determined upon as best to blow the furnace is not necessarily the best for developing power for sale. In fact in my judgment the probabilities are that the reverse is the case. The steam turbine owing to rotary motion, high steam economy, and ease of supervision has great advantages in driving electric generators, whereas for driving blowers it has no better means to apply to the purpose than the turbo blower whose efficiency is only 70 per cent as a maximum as compared with 85 per cent or more as the over-all efficiency of the piston blower. This gives the reciprocating engine, whether steam or gas driven, a long lead over the turbine for blowing purposes, while it has as outlined above many advantages over them in the generation of electric power.

For all these reasons it seems well to reiterate that each case presents a problem of its own which must be handled without prejudice by someone competent to weigh not only the technical considerations involved, but also that more serious and more difficult question which has wrecked so many engineers and their brilliant schemes: *How much interest will it pay on the capital invested?*

---

## Notes on Chemistry and Metallurgy in Great Britain

*(From Our Special Correspondent)*

### The Institution of Mining and Metallurgy

At the annual general meeting of this institution, on March 26, Dr. F. H. Hatch delivered his presidential address and took as his subject "The Relation of Geology to Mining." He said that originally the science of geology was founded to a considerable extent on the facts observed by miners; but at the present the situation has become reversed and mining is largely dependent on geology. There were many instances of successful mining operations resulting from the application of geological science: but the importance of geology in relation to mining was even greater than was generally recognized; and its due appreciation would involve either a more extensive training in geology on the part of the mining engineer or the cooperation of the mining geologist. With regard to modern views on the origin and formation of metalliferous ores, it was remarkable that British geologists, with very few exceptions, appeared to look on the questions of ore-deposits as a matter exterior to pure geological science.

It was announced that the number of members of the institution on December 31 last was 2,372, an increase of 114 during the year 1913.

### The British Westinghouse Company

The report for the year ended on December 31, 1913, shows that the position of the British Westinghouse Electric and Manufacturing Company has undergone a material improvement; and contains the satisfactory announcement of a 5 per cent dividend on the 15 per cent Preference Shares. The gross profit for the year is £223,103, out of which £44,100 for depreciation, £6,728 for redemption of Six Per Cent Prior Lien Debentures, £13,272 for interest on the Six Per Cent. Prior Lien Debentures, £49,645 for interest on Four Per Cent Mortgage Debentures, and £2,856 for expenses on surplus land and buildings are deducted; leaving £106,494 net profit. The dividend on the Preference Shares absorbs £50,000; £50,000 are carried to general reserve, and the balance of £6,494 is carried forward. The balance brought forward from 1912, amounting to £66,899 was devoted to the reduction of capital.

### FLAMELESS COMBUSTION

Professor **W. A. Bone**, in a recent lecture at the Royal Institution, described the principles and applications of the system of surface combustion devised and carried out at Leeds by himself and Mr. C. D. McCourt.

In its simplest form the apparatus for incandescent flameless combustion consists of a diaphragm of porous refractory material mounted in a suitable casing forming a chamber into which an explosive mixture of gas and air, in the proportions requisite for complete combustion, is admitted under slight pressure. Combustion goes on at and under the surface of the diaphragm, which becomes highly incandescent, without flame, and is limited to a depth of about 0.25

inch below the surface. Temperature is perfectly controlled by varying the rate of supply of the gaseous mixture, and the apparatus works efficiently in any desired position. The external air does not take any part in the combustion, and incandescence can be maintained in an atmosphere of carbon dioxide.

For furnace operations, heating crucibles and muffles, and annealing, the body or substance to be heated is surrounded by a bed or layer of refractory material enclosed in a suitable chamber and the gaseous mixture is injected into the poruos bed at a speed high enough to present back firing. A No. 39 Seger cone with a melting point of 1880 deg. C. has been melted in a crucible fired by a coalgas-air mixture; platinum can be melted without difficulty, and the temperature of a muffle can be maintained at 800 deg. to 1400 deg. C. with a gas consumption from 30 to 60 per cent less than that of an ordinary flame furnace of the same size. Satisfactory reports have been made on the working of some large annealing furnaces using Mond gas and town gas, and the melting of 50-lb. to 60-lb. charges of brass in tilting crucible furnaces has been effected with a consumption of only about 1.75 cu. ft. per pound of metal melted. The process admits of the use of any kind of gaseous or vaporized fuel of the requisite calorific value.

The great value of the invention in its application to steam boilers has been proved in practice. The heating tubes have an internal diameter of 3 in., and are packed with refractory material into which the gaseous mixture is forced through an inlet in the center of a plug of fire-clay, closing one end. Trials of a boiler so heated, at Skinningrove Iron Works in July, 1912, after five months' working, showed the utilization of 92.7 per cent of the net heat supplied, while 4.3 per cent was lost by radiation, etc., and 3 per cent in the products of combustion, but none at all in unburnt gas. A second installation has recently been made at the same works, and the firm of Krupps has been successfully using a boiler heated on the Bone-Court system since last October. Reports of the official steam trials of this boiler early in February confirm the results obtained at Skinningrove. The lecturer complained of this "purely all-British invention,"[1] having been described in the German technical journals as the "Bone-Schnabel" or "Schnabel-Bone" boiler instead of the "Bone-Court."

### Determination of Zinc in Bronze Coinage

Dr. T. K. Rose, assayer of the Royal Mint, read a paper before the London Section of the Society of Chemical Industry, in which he said that it had been decided to revive the old method of estimating zinc in coinage bronze which was abandoned about the year 1870. That old method had a great advantage in economizing the time occupied, and in fact, demanded only about five minutes personal attention for each estimation.

The method was very simple and was effected by heating one gramme of the alloy in a reducing atmosphere at a temperature of 1375 degrees for two hours and taking the weight of the residue. The details are as follows:

The one gramme sample is placed in a carbon crucible provided with a well-fitting lid, and from 8 to 16 of these crucibles are imbedded in charcoal in a graphite pot and subjected to the temperature named in an injector furnace. The composition of coinage bronze is copper 95 per cent., tin 4, and zinc 1. The loss after two hours' heating as described was found to amount to between 1.2 and 1.3 per cent., which was explained by the fact that whilst about 0.03 per cent. of the zinc was retained there was a large loss of copper, amounting to about 0.2 per cent.

With each batch of assays a sample from a trial plate of known composition was included, and the results, after correction, showed a variation of from 0 to 0.1 per cent., the average coming out at about 0.02 or 0.03 per cent.

Determinations have been carried out by this method, on alloys of zinc containing various amounts of that metal, up to as much as 90 per cent., and the results obtained were in very good agreement with those furnished by gravimetric and volumetric methods.

A noteworthy fact, however, was that as the percentage of zinc increased from 1 to 90 the copper loss during the heating grew to twice as great and rose to 0.4 per cent.

### Market Prices, March, 1914

*Tin* opened £174, and fell away to £172-£173, about which price it remained till the 17th, hardening to £174.5 on the 18th and to £175.5 on the 23rd, and touching £176.10 on the 24th, since easier and closes at £173.10.

*Copper* opened at £64, and declined gradually to £63.7.6 (13th), recovering to £64 on the 19th, and to £64.13.9 on the 23rd, and rising as high as £65.7.6 on the 24th; then eased slightly, closing at £64.17.6.

*Haematite* remains firm at 61/- and closes at the same price.

*Cleveland* opened at 50/6 and has remained close to this price; it was 50/4½ on the 13th and 50/9 on the 18th, since easing slightly, but closing at 50/9.

*Scotch Pig* opened 56/6 and has been either at or close to this price, closing, however, a little higher at 56/9.

*Lead* opened at £20 and was at first inclined upwards, being £21.10 on the 10th, and, after a drop of 2/6 on the 13th and 16th, it became rather quieter, closing £20.5.0.

*Differences*

| *Higher* | £ s. d. | *Lower* | £ s. d. |
|---|---|---|---|
| Copper ore, unit ..... | 4½ | Aluminium, ton ....... | 1. 0. 0 |
| Copper, ton ......... | 10. 6 | Caustic soda, ton....... | 5. 0 |
| Lead ............... | 5. 0 | Quicksilver, flask ...... | 10. 0 |
| Cleveland ........... | 3 | Sulphate of ammonia... | 6. 3 |
| Scotch pig .......... | 3 | Shellac, cwt. .......... | 2. 6 |
| | | Tin ore, ton............ | 6. 0. 0 |
| | | Tin, ton .............. | 2. 0. 0 |

| | £ s. d. |
|---|---|
| Aluminium, ingots, ton lots.......................... | 85. 0. 0 |
| Alum, lump, loose, per ton....................... | £5.5 to 5.10. 0 |
| Antimony, Star Regulus, per ton................. | £28 to 29. 0. 0 |
| Borax, British refined crystal, cwt................ | 17/6 to 18. 6 |
| Copper sulphate, per ton............................ | 22.10. 0 |
| Caustic soda, 70%, per ton.......................... | 10. 0. 0 |
| Copper ore, 10% to 25%, unit.................. | 10/10½ to 11. 4½ |
| Ebonite rod, lb. ....................................... | 4. 6 |
| Hydrochloric acid, cwt. .............................. | 5. 0 |
| India rubber, Para, fine, lb............................ | 3. 0 |
| Mica, in original cases, medium...................... | 3/6 to 6. 0 |
| Petroleum, Russian spot, gal.......................... | 9¼ |
| Quicksilver (Spanish), bottle.......................... | 7. 0. 0 |
| Sal ammoniac, cwt..................................... | £2 to 2. 2. 0 |
| Sulphate of ammonia, ton............................. | 12. 6. 3 |
| Sulphur, recovered, ton................................ | 5.10. 0 |
| Shellac, cwt. .............................................. | 3.11. 6 |
| Platinum, oz., nominal................................. | 9. 5. 0 |
| Tin ore, 70%, ton.................................. | £107 to 109. 0. 0 |
| Zinc, Vielle, Montagne.................................... | 25.12. 6 |

Steel castings direct from iron ore are now being made in the electric furnace by the Moffat-Irving Steel Works, Toronto, Canada, according to the *Canadian Engineer*. Average analysis of three heats is reported as C, 0.27 per cent; Mn, 0.74 per cent; Si, 0.27 per cent; S, 0.01 per cent; P, 0.031 per cent.

Electric furnaces of the Heroult type are used by the National Malleable Castings Company at the plant at Sharon, Pa., for the manufacture of electric steel castings for automobile and locomotive parts. A booklet issued by the company gives information regarding the advantages of electric steel castings.

---

[1] Concerning the early American work of Dr. Chas. E. Lucke on surface combustion see this Journal, Vol. X, page [illegible] (July 1912.)

# New York Convention of American Electrochemical Society

## Report of Proceedings, and Abstracts of Lectures and Papers Presented

The twenty-fifth general meeting of the American Electrochemical Society was held in New York City on Thursday, Friday and Saturday, April 16, 17 and 18. The attendance was excellent, there being more than 300 members and guests registered, and the meeting was a success in every respect.

The arrangements of the meeting were in the hands of the New York Section of the Society and the fullest credit must be given to the untiring efforts of its officers, Mr. Lawrence Addicks, chairman, and Mr. H. B. Coho, secretary and treasurer, as well as to the chairmen of the committees which had the different social functions and entertainments in their care. Mrs. L. H. Baekeland was the chairman of the Ladies' Committee, Mr. Lawrence Addicks was in charge of the steamer excursion on Friday, Mr. H. B. Coho of the smoker on Thursday night. Mr. Jacob Hasslacher, as chairman of the finance committee, made possible a lavish entertainment of the visitors. Mr. George C. Stone was in charge of the dinner-dance on Saturday night, Professor Arthur L. Walker was chairman of the reception committee, while the *Convention Daily*, published in three issues by courtesy of *Metallurgical and Chemical Engineering*, was in charge of Mr. J. Malcolm Muir, as chairman of the Publication Committee, and Mr. H. C. Parmelee as editor.

F. AUSTIN LIDBURY,
PRESIDENT AMERICAN ELECTROCHEMICAL SOCIETY

### Business Meeting

The annual business meeting of the Society was held at the beginning of the first technical session on Thursday morning at The Chemists' Club. President E. F. Roeber called the meeting to order at 9 a. m. and Mr. Lawrence Addicks, chairman of the New York Section, extended in a felicitous little speech the greeting of the New York members to the visitors.

Dr. J. W. Richards then presented the annual reports of the secretary and treasurer, which showed the Society to be in a flourishing condition. The number of members on Dec. 31, 1913, was 1376; it is now about 1400. The assets of the Society, invested in bonds, amount to over $6,000.

Dr. W. R. Whitney called the attention of the members of the Society to the organization of the International Electrical Congress, which will convene in San Francisco next fall. The American Electrochemical Society will hold its fall meeting of 1915 in connection with the Electrochemical and Electrometallurgical Section of this Congress.

The result of the annual election of officers was then announced as follows:

Mr. F. Austin Lidbury, works-manager of the Oldbury Electrochemical Company, Niagara Falls, N. Y., is the new president.

Mr. Pedro G. Salom and Dr. Joseph W. Richards were re-elected treasurer and secretary respectively.

Dr. Carl Hering, Dr. Wilder D. Bancroft and Dr. William Brady were elected vice-presidents; Mr. H. C. Parmelee, Dr. W. R. Whitney and Dr. Colin G. Fink, managers.

### Smoker

On the evening of Thursday the retiring president, Dr. E. F. Roeber, presented at The Chemists' Club his address on "Some Economic and Aesthetic Aspects of Electrochemistry." This is printed in full on page 344.

This was followed by a smoker which was very entertaining. The idea of the smoker was Election Night of Section Q. Mr. Coho, as chairman of the smoker, explained that at the last general meeting of the Society in Denver a certain wealthy mine owner was so impressed with the serious worth of Section Q that on his death he bequeathed to the section a complex-zinc-ore mine in Mexico. The question immediately arose, "What shall be done with the mine?" It was finally decided to hold an election to select a group of men and a process and work the mine. Three tickets had been in the field and the electioneering had been furious.

The Wet Party advocated a wet process for treating the ore. The Drys favored dry ore treatment, while a third party had arisen from the desire of the Bureau of Mines to run this mine and after an amalgamation with the I. W. W. advocated a fusion process.

Mr. Coho explained that the election returns were now coming in and that bulletins from various districts would be flashed on the screens. These bulletins were a source of much pleasure, being appropriately grotesque. Between bulletins the stereopticon operator flashed portraits of members of the electrochemical rougue's gallery, with verses setting forth their accomplishments in nursery rhymes. Then there were moving pictures, songs and presentations, mixed with the enjoyment of beer, pretzels and cigars.

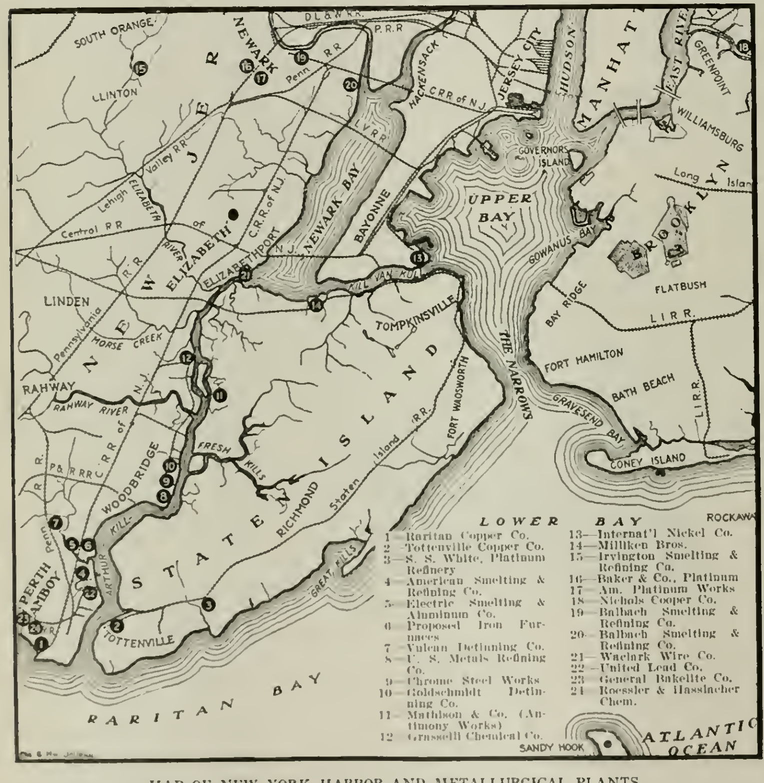
An election bulletin finally announced that the complete count of the ballots showed that the candidate of the Wets had received 6000 votes, the Fusion candidate 505, and the candidate of the Drys 2 votes, whereupon, in accordance with the new constitution of Section Q, the result was referred to the Council for final action.

In the meantime the candidate of the Wets, being apparently the successful candidate, was called on for a speech. He was interrupted, however, by the announcement that the Council had met and unanimously elected the Dry candidate president of Section Q and director of the zinc mine. Just here a wireless was received to the effect that the Fusion candidate protested agains the high-handed methods of the Council.

The fun was greatly enjoyed. About 11 o'clock a Dutch lunch was served and the members dispersed at a late hour.

### Boat Excursion on Friday

The boat excursion on Friday, in charge of Mr. Lawrence Addicks, had been equally carefully planned. The steamer *Isabel* had been hired to take the party down through New York Harbor to the Narrows and then around Staten Island to Perth Amboy.



MAP OF NEW YORK HARBOR AND METALLURGICAL PLANTS

The rain of Wednesday and Thursday threatened to spoil the excursion and there were many silent prayers for a change in the weather. When Friday morning came it was a beautiful day and nearly 200 members and guests with ladies participated in the steamer trip. The sights of New York Harbor were greatly enjoyed in the crisp spring morning. The entertainment on board included music and dancing, a luncheon and tea.

The works of the American Smelting and Refining Company at Perth Amboy and the adjoining plant of the United Lead Company were visited in the early afternoon and on the return trip the copper wire-drawing mill of the Waclark Wire Company in Elizabethport. A separate party went from Perth Amboy with Mr. Alfred H. Cowles to his plant in Sewaren, where his new alumina process is being tried out on a large scale.

The accompanying map shows the location of the plants visited; it is reproduced here from the *Convention Daily*. The map had been published originally in the *Engineering and Mining Journal*, but for the purpose of illustrating the boat trip the names of a few plants have been added. The map is interesting in illustrating New York City as a metallurgical center.

### Dinner Dance

The meeting was concluded by a dinner dance in The Chemists' Club on Saturday night, in charge of Mr. George C. Stone. The banquet was held in Rumford Hall. Mr. Lawrence Addicks was a very clever toastmaster. Speeches were made by the retiring and incoming presidents, Roeber and Lidbury, by Professor Bancroft, and by Mrs. L. H. Baekeland, whoe spoke beautifully of the proper sphere of influence of the modern woman. Dr. L. H. Baekeland then presented to the retiring president, Dr. Roeber, a beautiful silver loving cup "from his many friends."

Dancing followed in the social rooms of The Chemists' Club and was indulged in by a large party up to a late hour. Thus the twenty-fifth meeting of the American Electrochemical Society went into history.

### Ladies' Entertainment

Mrs. L. H. Baekeland was the genial chairman of the Ladies' Committee and a very fine programme of entertainment had been arranged, including a Thé Dansant at the McAlpin on Thursday afternoon, a theater party, in charge of Mrs. Maximilian Toch, on Thursday night ("Too Many Cooks"), a visit to the Morgan picture collection and an automobile party on Saturday morning, and a tea at the Plaza on Saturday afternoon.

### Technical Sessions

There were four technical sessions. Those of Thursday morning and afternoon were held in The Chemists' Club and those of Saturday morning and afternoon at Columbia University. All these sessions were opened by invitation lectures, followed by the reading and discussion of papers, of which printed advance copies were available. The attendance at all technical sessions was very good; it was never below 100, and often reached 200 present.

### Power Problems in Electrochemistry

The subject of the first technical session held on

Thursday morning in The Chemists' Club was a symposium of lectures and papers on power problems in electrochemistry, followed by a general discussion. The session was very well attended and lasted from 9:15 a. m. to 12.45 p. m.

### Characteristics of Electrical Energy as Affecting Chemical Industries

**Dr. Charles Proteus Steinmetz** presented a lecture on characteristics of electrical energy as affecting chemical industries. Industrial operations require materials, energy and labor. While the economical supply of energy is important for most industries, it is especially so for the chemical industries. In the chemical industries the cost of materials and energy predominates greatly over that of labor.

Energy is supplied to us by nature essentially in two forms, namely, the chemical energy of fuel, and the hydraulic energy of water powers. Considered merely as the raw material, as bulk source of energy, the chemical energy of fuel is very much cheaper. The lowest cost of energy of fuel as such is 0.01 cent per kw-hour, against 0.1 cent for electric energy from water powers. Hydroelectric energy can compete with the chemical energy of fuel only in those cases where there are compensating advantages.

CHARLES P. STEINMETZ

There are two such cases. First, where electrical energy can accomplish chemical results which cannot be accomplished by the chemical energy of fuel; such processes are reduction of aluminium, production of calcium carbide, and fixation of atmospheric nitrogen. Second, where the economic losses in efficiency and in cost of installation, and economic losses of making chemical energy of fuel available by converting it into the form in which it is used, are such as to make the cost of the energy required by the industry when derived from the chemical energy of fuel higher than the electrical energy derived from water power. The most typical illustration of this kind is the mechanical energy supply. While the chemical energy of fuel costs about one-tenth of what the electrical energy from the water power costs, when we convert the chemical energy of fuel into mechanical energy by steam plant, considering the interest on the investment and the inefficiency of the thermodynamic process as a whole, we find that almost always the cost of the mechanical energy derived from chemical energy of fuel is higher than when derived from the electrical energy transmitted from the water power, other things being equal.

One of the characteristics which makes electrical energy specially suitable for chemical industries is the possibility of concentration to an almost unlimited energy density, so that by electrical energy we can bring about chemical actions which cannot be brought about by the relatively low energy density available by combustion of fuel.

In electric furnaces we can reach temperatures very much higher than the highest temperature possible by the combustion of fuel, even with hot blasts and other auxiliaries. In those fields where a higher energy density is required electrical energy stands without a rival, irrespective of the cost, and the economy of energy supply merely determines the cost of selling and therefore the utility of the product in the industry.

A second characteristic of electrical energy is its control. We can control it very much more closely than the chemical energy of fuel in form of chemical combustion. We can produce electrical energy without contamination by foreign materials. Therefore, electrical energy finds application in chemical or other industrial processes, where a very close control of the energy is called for, and where the contamination by foreign materials, which is practically unavoidable when fuel is used as the source of energy, would be prohibitive.

Another characteristic of electrical energy is its ease and economy of transmission to great distances and its economical distribution, but its predominating advantage is the ease of its conversion into other forms of energy with a very high economic efficiency.

There is, however, one characteristic of electrical energy which is a very serious disadvantage, and that is that electrical energy cannot be economically stored, but must be consumed at the same rate at which it is produced. This makes the cost of electric energy dependent on the rate of its consumption, in the same manner as the cost of energy is dependent on the rate of its production. The cost of electrical energy generated in the same big power station may vary in a range of more than 1 to 200; that is, power may be sold economically and profitably at ½ cent, or less, per kw-hour at times of low load, while power generated during the hours of the peak of the load may cost the station more than $1 per kw-hour. In the analysis of the cost of electrical energy production proper consideration of the fixed charges of the plant is very important. This is particularly true of hydroelectric plants. The station load-factor dominates the cost of energy production.

To secure electrical energy at the lowest possible cost for chemical work it must be used at constant load and continuously day and night throughout the entire year, in other words, at unity load-factor at the consumers' premises.

In electric-furnace work a reactance may be used to intentionally limit the maximum demand. While this would lower the power-factor, this is of less importance in most cases than to exceed a certain maximum demand, because a poor power-factor can be corrected by synchronous condensers at relatively smaller cost than additional generating capacity can be secured to carry peak loads.

As most water powers are subject to limitation of output by low flow of water during certain times of the year, any industry that can afford to shut down entirely or at least partly for several weeks or even months during the drought can reduce the cost of its electrical energy supply. This means that conditions may require an annual shutdown, even with employees receiving full pay, and better net financial results may be obtained in this way than by absolutely continuous operation.

Another possibility of reducing the power cost is the possibility of sudden shutdown, from a minute or so to possibly several hours, on account of failure of transmission lines, because this eliminates the necessity of a steam reserve plant.

The very lowest rate for power can be obtained by those industries which can utilize intermittent and distinctively off-peak power in such a way as to fill the valleys in the station's load curve and bring the station load-factor nearly to unity. The rate for such a load should be considerably lower than for one taking continuous power throughout the year. If electrochemists can build up such a load, they will get the electric power at the very lowest rates.

### Power Transmission Economics

Mr. **P. W. Sothman**, of P. W. Sothman Co., consulting engineers, New York City, presented a paper entitled "Notes on Power Tranmission and Transmission Economics," with special reference to the economy of power transmission versus utilization in local electrochemical industries.

The author first discussed electric power generation from steam, waterfalls, gas producer plants and oil engines, and expressed the belief that the time would shortly arrive when power generated from gas and oil in competition with steam and water power would take a very prominent place in electrochemical work. He gave figures for the initial costs of power plants of the different types, including buildings, and for the cost of electricity per kw-hour on the busbars so developed, including all overhead and maintenance charges. These figures are given in Table I:

P. W. SOTHMAN

TABLE I.

| | Hydroelectric Plant | Steam Plant | Gas Producers | Diesel Plant |
|---|---|---|---|---|
| Initial cost per h.p. of capacity ......... | $125 | $100 | $100 | $100 |
| Power cost per kw.-hour .... | 3.6 mills | 6.25 mills | 4.95 mills | 5.62 mills |

These figures are based on a load factor of 60 per cent. and include fixed charges of 11 per cent. on the hydroelectric and steam stations and 12 per cent. on the gas producer and Diesel plants. The high load factors which are attainable in large electrochemical plants favor not only water power plants but also those operated by producer gas and oil, for the high efficiencies of the latter two are most marked when the load factor is good.

Table II. was published a couple of years ago and shows horsepower used per employee in a number of industries:

TABLE II.

| | Horsepower Used Per Employee |
|---|---|
| Tools and implements.................. | 0.678 h.p. |
| Cotton and woolen goods................ | 0.759 " |
| Miscellaneous manufacture............. | 2.35 " |
| Paper manufacture .................... | 13.33 " |
| Flour and feed........................ | 15.93 " |
| Lumber and woodworking............. | 6.76 " |
| Pulp grinding and excelsior............ | 23.00 " |

In electrochemical industries power forms one of the chief items of expense of operation.

In discussing transmission of electrical power Mr. Sothman mentioned that transmission at 10,000 volts was first attempted in 1891; in ten years' time the voltage climbed to 50,000, while before the end of 1909 lines at 110,000 volts were in operation. Now the mark has been set at 145,000 volts. The operator of electrochemical works should inquire whether this marked development in transmission cannot be taken advantage of by himself. But each case must be studied for itself.

How far is it possible to transmit energy electrically in usable quantities? Power in any amount may be easily transmitted on a straightaway line for a distance of at least 500 miles, and at that in a thoroughly reliable manner, though at the farther end of the line perhaps only 65 to 75 per cent. of the power may be received, even with the use of liberal-sized conductors.

At the present time there are no less than three long-distance lines in operation at approximately 145,000 volts, and the length of each is close to 240 miles. These are doubtless all well within the present economical distance limit.

In districts where a cheap coal supply is available, such as in certain parts of the East, it is not profitable to transmit power to greater distances than about 175 miles, even when competing with steam, for if the power is required in such quantities as to warrant the construction of a substantial transmission line, it would also warrant the building of a modernly equipped steam plant on the site of utilization which could supply energy at a cost as low as that of the transmitted power.

The use of a modern gas producer, burning coal costing $2 per ton, reduces the economical transmission distance of waterpower costing to generate four mills per kilowatt-hour to approximately one hundred miles.

Mr. Sothman next discussed the choice at voltage. The reason for using high voltage is to keep the conductor cost as low as possible. But with high-voltage lines there are other factors of expense which offset the saving in the size of conductors. Wooden-pole lines with low-priced pin-type insulators may be used for voltages up to 40,000 or 50,000. At 60,000 volts steel towers are almost universally used, the cost of which is higher. As the voltage further increases very expensive pin-type insulators or suspension-type insulators are used. At potentials upwards of 100,000 volts, the effects of corona become manifest. The critical voltage at which corona starts becomes lower with smaller-sized conductors.

In Mr. Sothman's opinion there should be no need of an intermediate voltage between 60,000 and 110,000 volts. The author discussed in some detail the great advances made in insulator design in recent years.

In conclusion Mr. Sothman gave some figures for the costs per mile of transmission line construction suited to different voltages. These are based upon the use of copper cables of No. 000 B. & S. gauge or their equivalent in aluminum. These figures are given in Table III. These costs do not include a telephone line or right-of-way. The wooden poles are assumed to be spaced 120 ft. apart and the steel towers 550 ft. apart. In the total cost of line 10 per cent. has been allowed for engineering and contingencies.

With proper care in the design and selection of materials, specially insulators, coupled with the use of suitable protection apparatus, a modern line should give practically uninterrupted service. But each particular case must be considered upon its own merits. For instance, an insulator may serve admirably on one line and fail utterly to give satisfaction on another line of the same voltage.

In conclusion Mr. Sothman called attention to the value of the peat deposits distributed all over the country. They may become more valuable for power supply than our waterpowers, especially as they are not liable to interruptions like waterpowers. A point

TABLE III.

| Description | Towers or Poles Inc. Footings | Cables and Erection | Insulators | Total |
|---|---|---|---|---|
| 12,000 volts. | | | | |
| Pole Line | | | | |
| Double circuit.. | $1,400 | $3,120 | $130 | $5,115 |
| Single circuit.. | 1,100 | 1,600 | 65 | 3,042 |
| 30,000 volts | | | | |
| Pole Line | | | | |
| Single circuit.. | 1,400 | 1,650 | 200 | 3,575 |
| 60,000 volts. | | | | |
| Steel Towers | | | Pin Type | |
| Double circuit.. | 1,800 | 3,300 | $220 | 5,852 |
| Single circuit . | 1,630 | 1,700 | 110 | 3,784 |
| 110,000 volts | | | | |
| Steel Towers | | | Suspension Type | |
| Double circuit.. | 2,050 | 3,300 | $662 | 6,569 |
| Single circuit.. | 1,850 | 1,720 | 350 | 4,312 |

Copper based on 18c. per lb.

may be reached where the use of peat power plants in conjunction with water power plants may prove advantageous.

### Economies of Electric Furnace Operations

Mr. **F. A. Fitz Gerald**, of The Fitz Gerald Laboratories, Inc., Niagara Falls, N. Y., presented a paper on "Some Economies in the Use of Energy in Electric Furnaces."

"The relatively high cost of the heat unit generated by means of electricity as compared with fuel has led all those interested in the development of electrothermics to give serious consideration to economies in electric furnace practice. While the end sought is most desirable, it is unfortunate that its pursuit has led to much misdirected effort, which, instead of realizing economies, has resulted in waste and consequent retardation in electric furnace development.

"This is not surprising, since the same thing is observed in the pursuit of many other desirable objects, such for example as conservation, efficiency, eugenics, etc. No one will deny that these things are important, and no intelligent observer can fail to see the vast amount of misdirected and even harmful activity generated in relation to them. Perhaps the most striking analogy is found in certain activities for the relief of human ills. Recently there has been extraordinary agitation in favor of inducing the government to take up the mining and manufacture of radium.

"Leaving out all such secondary motives as the creation of bureaucratic jobs, personal advertising, etc., it is found that many people, otherwise intelligent, believe first that cheap radium is one of the most important things for the welfare of the human race, and second that governmental meddling will result in the production of radium at a low cost. Now, as regards the first belief, we do not yet know the extent to which radium is applicable as a curative agent, but, however important it may be, there is no doubt that its relative importance to human welfare in general is grossly exaggerated. As regards the second belief, even a superficial knowledge of the subject shows that while governmental meddling may mean selling radium at a lower *price*, its production will be at a greatly increased *cost*, since in all lines of activity outside its proper functions there is no more inefficient and expensive machine than a government.

"In electric furnace practice we have analogous error which is made in the name of economy; first in attaching an exaggerated importance to the saving of the heat units generated by the electric current, and second in the inefficient and expensive machinery used for the purpose, with the result that in slightly increasing the efficiency of the furnace there is a greatly increased loss of energy.

"In attempting to realize energy economies in electric furnace practice the first consideration should be the conditions governing the cost of power, and this can best be illustrated by abstracting parts of a typical power contract:

"1. The power company agrees to deliver so many horsepower 24 hours each day and every day in the year for a period of years.

"2. In case the purchaser's requirements are greater at times than the firm horse power agreed to be taken and paid for, the power company agrees to supply such intermittent demands, but in that case the amount to be paid for is the average of the highest daily one-minute peaks occurring during the month for which the charge is made.

"3. By "firm power" is meant the amount of power agreed to be taken and paid for by the purchaser *whether or not he uses it.* By "intermittent demand" is meant the highest one-minute peak occurring during any one day.

"4. The purchaser must when possible take current equally from the three phases, but whenever it is impossible and the difference between any two phases is greater than ten per cent. of the lesser he shall pay for power as though the current taken from each phase was equal to the greatest amount actually taken from any one phase.

"5. The purchaser must always maintain a power factor as near 100 per cent. as possible, but whenever this is less than 90 per cent. the average intermittent demand shall be considered as 90 per cent. of the maximum kilovolt-amperes taken for a period of one minute each day except that the average intermittent demand shall never be considered less than the firm horse power agreed to be taken and paid for.

"The trouble with many, indeed most, experimenters who are trying to start commercial plants, and even with some plants that are running commercially, is a failure to recognize the significance of the power contract. The important consideration in the plant, so far as energy economy is concerned, is that from the time the current is thrown on 100 *per cent of it must be used* 24 *hours each day and every day in the year.*

"Instead of this consideration being the first one, it is continually neglected in the pursuit of some fad such as increased efficiency in the use of heat units or saving some waste gases or working a complicated continuous instead of a simple discontinuous process. The result is that the exaggerated importance attached to these ends, desirable in themselves, leads to load factors far below 100 per cent. or to peaks involving expensive intermittent charges or to shutting down to repair or adjust complicated machinery built in the name of efficiency, while there is never any shutting down of the power company's bills.

"A general review of electric furnace work during past years shows that a great waste has resulted from the efforts of inventors working on smelting problems because they have attempted to develop elaborate schemes for preheating furnace charges, for utilizing CO gas, to obtain preliminary reduction, etc., before they have thoroughly worked out the simple furnace problems free from efficiency devices.

"The fundamental error of this work is the attempt to force too rapidly the natural evolution from the simple to the complex. Returning to our radium analogy, we have here another case of mistaken zeal in attaining an end desirable in itself, but relatively insignificant, so that much waste results from the use of cumbersome and inefficient machinery.

"Another wasteful notion dear to the inventor is the continuous process furnace. In many cases continuous furnaces are apt to mean complicated and expensive furnaces. One of those probably costs as much as several discontinuous furnaces. If an accident happens to one of the latter there is generally another ready to go on, but with the expensive continuous furnace there often is no spare one, or if there is it takes a long time to get it tuned up to normal working order, and meanwhile the power bill is eating up profits. The exaggerated importance attached to the continuous process has done harm in another way, for it has seriously retarded the development of processes for the utilization of off-peak power. This, obviously, requires discontinuous work, which has got a bad name, thanks to the efficiency idealist.

"Incidentally, it may be mentioned that a preliminary study of the off-peak problem is distinctly encouraging, but I do not believe that it will ever be worked out until it is taken up seriously by those having power to sell rather than by the consumer.

"After making sure that the consumption of power in a furnace plant will be continuous, the next step is to keep the power at 100 per cent. of that called for in the contract. In furnaces, of which that used for making silicon carbide may be taken as the type, there is after starting a rather gradual decrease in resistance, so in order to keep the power constant some means of regulating the voltage must be used. The cheapest way of doing this is to have a step by step method in connection with the transformers, but unless the steps are very close together it is not economical. A step by step device gives a load curve that looks like the teeth of a saw, and at the end of the year the energy wasted, represented by the spaces between the teeth, will pay for apparatus giving closer voltage regulation.

"In arc furnaces we have extremely sudden changes of resistance which should be taken care of by automatic regulators. These are very commonly looked on simply as labor-saving devices, but they are just as important as savers of energy. They avoid peaks, a fruitful source of expense, and keep the balance between the three phases. In a plant with which I am acquainted the installation of automatic regulation has increased the furnace yield somewhat over 10 per cent.

"As regards the question of power factor, this is not usually troublesome, except in the case of such an apparatus as the induction furnace. In this case much may be done by the use of a suitable condenser. Thus, very satisfactory results were obtained in the case of the American Electric Furnace Company's plant in Niagara Falls by the use of a synchronous motor with over-excited field coils. It was shown that in a plant of the kind running commercially the cost of the synchronous motor would be a good investment on account of the saving in the power bills.

"As a final useful suggestion in relation to energy economies I may mention that in some cases it is possible to provide a furnace or furnaces used to absorb any power which might otherwise be wasted for one cause or another."

## Power for Electric Furnace Work

A paper by **Mr. W. S. Horry**, of the Union Carbide Co., Niagara Falls, N. Y., on "Power for Electric Furnace Work" was read by title in the absence of the author, copies of the paper having been printed in advance. Mr. Horry pointed out that the electrochemical industries are rapidly outgrowing the available supply of electricity generated by the natural water powers of this country, so that in the near future they must inevitably be carried on with power generated from coal by some kind of prime mover. The extent to which the modern electric furnace requires energy is staggering. A single furnace some 16 ft. square will absorb 12,000 horse power. This amount of energy is sufficient for the light and power requirements of a small city, so it will be realized that all the available water power, great as it is, will not suffice for the needs of the electrochemical industry much longer.

It is fortunate that the production of electric power from coal has recently been simplified and cheapened. At present the cost of producing power by steam is low enough to be considered as rivaling the cost where water power is employed under the conditions that generally rule in the practice of electrochemistry.

The essentials for cheap power production from coal are close proximity to the coal mines, where plenty of water is available for condensing and where transportation facilities are adequate. The other requirements are met by the very nature of electrochemical processes. The load factor certainly will be 100 per cent and the power factor, which also enters into the costs, can be kept round 93 per cent at the switchboard even with the largest types of three-phase furnaces. Then, the first cost is kept down from the fact that it is not necessary to duplicate the generating machinery, modern boilers and turbines are quite reliable, and stoppages are remote and short and are such as not to constitute an objection for the purposes under review.

The actual prospective costs have been given by numerous contributors to other societies, such as Mr. H. M. Hobart, before the American Institute of Electrical Engineers. This author gives the investment cost as $35 per kilowatt for large powers generated at 60 cycles by steam turbine machinery and an operating cost of 0.25 cent per kilowatt hour as a minimum in cases where all conditions are favorable, and it is to be remarked that all conditions will at all times be favorable for such a plant in a properly chosen location, where electric furnaces constitute almost the entire load.

Mr. Horry thinks that Hobart's estimate is not too low or sanguine under the condition of operation of electrochemical industries. While the 25-cycle system is adequate for present requirements, the trend now seems to be to return to higher frequencies for general distribution. But large three-phase furnaces are not economically possible with a 60-cycle current. A scheme like the following may then be used:

The power of the three-phase, sixty-cycle furnace is limited. The cost of power is least when the power factor is unity. Therefore, good practice demands that this be kept high for the system as a whole and for the electric furnace in particular.

If we assume a power factor of 0.9, as measured on the high tension side of the transformers, and assume a delta voltage of 110, then the most power that a three-phase sixty-cycle furnace will take is about 2750 kilowatt, though by special design this figure can be somewhat improved. This is quite low. The modern smelting furnace is of decidedly greater capacity, to facilitate the extraction of its products.

But if this furnace be given six phases instead of three, it will take nearly double the power under the same conditions, while if twelve phases be chosen with twelve carbons in a ring at the furnace, then the power will be nearly four times that given, which would be sufficient for present requirements.

The six-phase secondary can be acquired by a mere change of the secondary connections from a three-phase transformer, and twelve phases can be similarly developed from two such transformers, one with its primaries connected delta and the other star fashion, the secondary voltages of the two being the same. Another function is then added to the transformers to increase the number of phases, as well as to lower the voltage, and, by this means, the even power produced from all dynamic machinery is reproduced within the furnace, although, for economical transmission, only three wires are employed in the line.

While the steam turbine seems at present the only device commercially available for 20,000-h.p. electric furnaces, it will not have the entire field to itself in the electrochemical industry. The gas engine is certainly the best prime mover in the steel industry, where blast-furnace gas is available in great quantities. The reciprocating steam turbine has likewise advanced.

The actual cost of electric power derivable from a modern steam plant is not, however, the only point of view for the electrochemist. He requires coal for preparing the materials for the electric furnaces. In electrothermal work it pays to roast the ore to be smelted and it pays to dry and prepare the coal used for reducing this ore. In other processes large amounts of coal are used to concentrate the solutions produced by electrolysis. Then it happens that a plant located where coal is cheap possesses advantages even if the cost of electric power from coal should be higher than that obtainable from a hydroelectric plant situated where coal is dear.

And finally there is always before the electrochemist the possibility of extracting the valuable constituents of the coal and of running the power plant with the residue. The byproduct coke oven produces sulphate of ammonia, tar, coke and gas. The two latter are of use to him in his process, and, if the two former can be profitably sold there would be a derived revenue that would operate to lower the cost of power. The scheme looks attractive for the reason that the byproducts can be extracted only to the extent that this is profitable, while the raw coal can be served to the boilers if its treatment before use is undesirable.

### Electric Furnace Regulators

**Mr. Robert Turnbull**, Welland, Ontario, Canada, then presented a paper on "The Thury Electric Furnace Regulator." The author discussed the advantages to be obtained from automatic regulation for the control of the current operating electric furnaces.

First, a great saving in wages, which for a three-phase furnace amounts to from 25 to 30 per cent. of the total labor employed on the furnace.

Second, a more efficient utilization of the current, resulting in maximum production, and shortening the time of the process.

Third, products of a higher and more uniform quality, owing to the steadier furnace conditions.

Fourth, the impossibility of mistakes, as the regulator always works in the proper direction and never without due reason.

The author then dealt in detail with the Thury regulator, pointing out its special advantages and describing its principle of operation. An account of this part of Mr. Turnbull's paper, together with illustrations, is reserved for our next issue.

### Power in Electrolytic Refineries

The following three papers were then read by title and called up for discussion, as they had already been read before the New York section of the Society:

"The Power Problem in an Electrolytic Copper Refinery." By **Lawrence Addicks.**

"The Power Problem in the Electrolytic Deposition of Metals." By **H. E. Longwell.**

"Sources of Direct Current for Electrochemical Processes." By **F. D. Newbury.**

An account of these three papers may be found in our issue of February, 1914, pages 91 to 94.

### General Discussion on Power Problems in Electrochemistry

A lively general discussion then followed.

Mr. Turnbull asked what would be a "reasonable" price for off-peak power in comparison with power used continuously 24 hours per day. There was no immediate reply from the many distinguished electrical engineers present, but, as will be seen below, Mr. Sothman gave later some interesting figures and still more characteristic advice later on.

Mr. Petinot spoke of the use of the Thury regulator and said its operation in connection with electric steel furnaces was as nearly perfect as could be desired. He had secured a regulation of load-factor as high as 97 or 98 per cent by the use of this regulator.

Mr. Lidbury thought that the different speakers had very naturally taken up the subject from their own points of view, and the papers showed that the point of view is an important factor in the consideration of any individual power problem. All speakers had shown, further, the great complications of their own particular phases of their power problem due to the very varied nature of electrochemical operations, in respect of size, the relative importance of power costs and the importance of other considerations that may enter into the problem. The horsepower used per employee varies in different electrochemical industries between 20 and 100 h.p. On account of this variety of conditions it is very dangerous to make generalizations without stating clearly the limiting condition. Mr. Lidbury finally said that there are enough electrochemical problems to solve, and operating engineers favor, above everything else, simplicity. He told the experience of an engineer in a concern where an elaborate "efficiency system" had been installed. When it had been in operation for a year and the efficiency expert called and asked how his efficiency system worked he was told it worked fine. "And how about business?" "Well, we have no time to attend to business now."

Mr. Hansen called attention to the fact that in general in arc furnaces, operating at low load, there is considerable wave distortion. As the load increases the wave distortion becomes less and less important.

Dr. Steinmetz said that wave distortion had been studied carefully 20 years ago in the case of the series arc-lighting system. The best advice that can be given on wave distortion in connection with electric furnaces is to get rid of it as soon as possible. The best means is reactance. If the power-factor is reduced by reactance we lower the wave-shape distortion and thereby eliminate the reduction of power-factor due to wave distortion. That means that where attempts are made to get as high power-factor as possible by cutting down all the reactance in the operation of the furnace the results have very often been disappointing. The mistake is made in most furnace operations to attempt to get a low reactance. Besides reducing wave distortion, reactances have the advantage that they prevent power fluctuations and balance the load on a three-phase system.

Mr. Lincoln, president-elect of the American Institute of Electrical Engineers, said that the calculation of the power-factor from the oscillograph record gives more correct results than a power-factor meter. If the current wave is of the same shape as the voltage wave, the power-factor meter gives the true power-factor, but if the current wave and the voltage wave are not of the same shape the power-factor meter does not give the true power-factor, and the latter must be determined in some other way. Wherever an arc is present, the current wave is not the same as the voltage wave. Mr. Lincoln thought that Hobart's figures for the cost of power from steam related to ideal conditions and could hardly be realized in practice.

Mr. Hansen explained that he had determined the power factor from oscillographic records and gave a very interesting account of the trouble experienced when the basic slag of an electric furnace evaporates and reacts with the silica roof.

Mr. Sothman thought it was agreed that the question of power is one of the most important in the electrochemical industry. In replying to Mr. Turnbull's former question he said he knew of Canadian contracts for power where the fundamental rate was $28.50 for power 24 hours a day for 365 days a year. If the consumer would permit shutting off 20 per cent of the power during the four winter months in the year for one and one-half hours per day that power could be had for $24, which is a reduction on the total power bill of about 22 per cent. In other cases reduction as high as 34 per cent had been made if it was off-peak power. If the amount of power per employee is relatively very large it pays to buy off-peak power. If there are ten men working on a certain process and 1000 horsepower is being used and off-peak power can be purchased 25 per cent cheaper it is more economical to buy the off-peak power, and lay the men off for an hour or two, provided the process is not in any way interfered with as to the final results. But in speaking of the cost of power it is very important to state clearly how the power is measured and where it is measured, and to look for the small gifts or no-gifts mentioned in the power contract. "Gentlemen, when you are about to sign a power contract open your eyes—open your eyes twice."

Dr. Hering, in commenting on Dr. Steinmetz's paper as eminently fair and clear, recommended it to the perusal of the power engineers, who seemed to be very slow to understand that it is to their interest to sell valley power quite cheaply.

### Policy of the Bureau of Mines

As the last subject of the Thursday morning session a letter by the Director of the Bureau of Mines, **Dr. J. A. Holmes**, dated April 15 and addressed to the President of the American Electrochemical Society, Dr. E. F. Roeber, was read by the Secretary, Dr. J. W. Richards. It is exceedingly interesting in defining the policy of the Bureau. Dr. Holmes' letter reads as follows:

"I regret exceedingly to find that important administrative matters in connection with the mine safety work of the Bureau will make it impossible for me to attend the meeting of the Electrochemical Society in New York tomorrow as I had intended doing; and also that these matters will prevent my being with the members of the Society during the steamer excursion Friday.

"I regret not being able to attend this meeting of the Society all the more for the reason that I anticipate a few of its members may have been misled by recent press dispatches as to the nature and extent of some of the Bureau's proposed work, especially in relation to the radium industry, and I might have been able to say something to correct misapprehensions along this line.

"In connection with the subjects which the Bureau is authorized to investigate it acts for the Government of the United States in the same way that any engineer or chemist may act for a private corporation by which he may be employed.

"Thus, for example, in relation to the radium industry, about which the press has of late had a good deal to say, the Government needs for use and especially for researches in its hospitals located in different parts of the country under the Public Health Service and under the Army and Navy, a certain quantity of radium, which at the prevailing market price will cost between $3,000,000 and $4,000,000. The chemists and mining engineers of the Bureau of Mines in a study of the radium-bearing ores on the public lands with a view to efficient development and the prevention of unnecessary waste, have developed methods of concentration and treatment through the use of which they estimate that the radium needed by the Government can be produced from ores now belonging to the Government at a cost considerably less than half of the existing market price. Other parties have discussed the subject and have framed legislation with a view to enlarging the scope of these operations; but the accredited representatives of the Bureau of Mines have neither planned or advised the extension of this work beyond the Government's own needs.

"Under somewhat similar circumstances a few years ago the Government was unable to purchase at what was considered a reasonable price cement for the construction of the Roosevelt Dam under the Reclamation Service. Under the circumstances a cement plant was erected on the ground, and an adequate supply of cement was manufactured and the dam constructed by the Government at a cost of nearly $1,000,000 less than the original bids by private parties. Nevertheless, no one recommends or expects the Government to go into the general cement manufacturing business.

"Insofar as its general work is concerned the policy and purpose of the Bureau of Mines is to help, and certainly not in any way to hinder, the professional work of private experts or the operations of private persons or corporations. Our work relates primarily to the public welfare, especially with relation to safeguarding the lives of employees, the prevention of unnecessary waste of resources, and the general advancement of the mining, metallurgical and other mineral industries. It is in the performance of this general public duty and in the carrying out of this general public purpose that I should be glad to have, and I feel sure the Bureau of Mines will receive, the hearty co-operation of the members of the Electrochemical Society."

A complimentary luncheon was served at 1 o'clock.

### Electrolytic Flames

After lunch had been taken in the social rooms of The Chemists' Club, the afternoon session began sharply at 2 o'clock with a most interesting experimental lecture by Professor **Wilder D. Bancroft**, of Cornell University, on electrolytic flames.

He called attention to the fact that metals do not give the same flame color for all of their salts. For example, sodium salts usually give a spectrum, but do not in a hydrogen-chlorine flame. There is probably metallic vapor in some flames, which tends to the dissociation of exothermic compounds in flame. This was proved by the precipitation of metallic mirrors from flames striking a water-cooled porcelain tube. This was illustrated by producing in a Bunsen flame mirrors of copper, silver, bismuth, antimony, arsenic, lead, tin cadmium and zinc. Molybdenum and tungsten salts do not give mirrors in the Bunsen flame, but fine mirrors of these metals were obtained from the oxy-hydrogen flame. Even sulphur can be thus precipitated on cold porcelain from sulphur dioxide, and red phosphorus from phosphorus compound.

We thus have evidence that many reactions take place in flames, and different reactions may cause the emission of different colors. For example, copper changed to cuprous ions in flame gives a green color; cuprous salt changed to cupric salt colors the flame blue; cuprous ion changed to cuprous salt colors the flame red. Tin changed to stannous salt gives carmine, but stannous salt to stannic salt gives green.

Many rapidly occurring chemical reactions emit light, and this is not confined to reactions taking place at high temperatures. Thus phosphorus oxidized by hydrogen peroxide gives colored phosphorescent light. Bromine oxidized by pyrogallol gives pale orange light. Mercury heated in bromine flame vaporizes at a very low temperature in an orange flame. This very clever experiment was beautifully performed.

Finally, the oxidation of bromine at an anode in potassium bromide solution, with a current voltage of only two volts was shown to give an orange-yellow glow at ordinary temperature.

W. D. BANCROFT

Professor Bancroft closed by stating that as a working hypothesis it appears that the conversion of the energy of the chemical reaction in a light increases as the temperature is lowered, and vice versa, thus explaining the common occurrence of luminescence at very low temperature as observed by Dewar.

Professor Bancroft's lecture was discussed by Messrs. Hambuechen, Tucker, Northrup and Whitney.

### Electric Steel Castings

Mr. C. A. Hansen, of the General Electric Company, then presented in abstract two papers on the electric furnace in the steel foundry, one by himself, the other by Mr. E. B. Clark, president of the Buchanan Electric Steel Company of Buchanan, Mich.

Mr. C. A. Hansen gave in his paper the results obtained with a 2-ton three-phase arc furnace in use since 1911 in the foundry of the Treadwell Engineering Company at Easton, Pa., which had taken over the work of an old crucible steel castings plant, making light section castings.

The cost of melted metal from the electric furnace was found to be somewhat less than one-half that of the old crucible furnace plant when the latter was using oil at 2½ cents per gallon. Since the advance in the price of oil has added $6.00 to $7.00 more to the cost per ton of molten crucible steel, the possibilities of saving in costs is readily apparent.

So far as the product is concerned, the most striking differences are not found in comparing electric and crucible steels of similar compositions. If any differences exist between such steels, they are negligible in importance, as repeated tests have shown.

Electric steel castings are usually made in lower carbons than it is possible to make from even clay-lined crucibles. In the latter it is perfectly possible to melt 0.20 carbon steel, but it is not possible to run the 0.20 carbon product regularly into light-section castings. As a result, 0.30 to 0.40 carbon castings are the usual output of the crucible steel foundry, and all castings which require machining must be annealed.

With the electric furnace, furnace maintenance costs increase rapidly as the carbon content of the product is brought down, and, quite contrary to current opinion, it is not economical to turn out 0.10 carbon steel castings, although it is perfectly possible to do so.

It is, however, economically practicable to turn out 0.20 carbon castings, and such castings can be machined easily without annealing. There is little question that all castings, whether 0.20 carbon or 0.30 carbon, can be improved by annealing, but the American attitude seems to be against the expense of annealing where annealing can be avoided.

Many have suggested charging molten cupola metal directly into the electric furnace for refining. In several such cases of which the author knows, the power consumption per ton of output was greater for the cupola metal charge than for the cold scrap charge; the original cost of the cupola metal was in the neighborhood of $18 per ton, as compared with $12 per ton for the regular cold charge, and the cost of furnacing was likewise higher for the cupola metal charge. The economy incident to heating the furnace with auxiliary fuel-burning apparatus may interest those who charge molten metal into electric furnaces, but the interest attaches rather to the prevention of skulled furnace bottoms than to a direct saving in electric energy. Heating the furnace and charge to a good red heat by means of oil burners (with oil at 2½ cents per gallon) increased the cost $1 per ton over the regular practice of all-electric heating. Keeping the furnace hot over night by means of either oil or electric energy was found not to materially decrease maintenance costs, and it did increase the cost of production. These items above refer to power supply at approximately 1 cent per kw-hour.

Much stress has been laid on the economy attaching to continuous operation of the electric furnace as compared with mere day-shift operation. So far as costs go for the molten steel, it is true that continuous operation means 10-15 per cent saving over intermittent operation. Very little has, however, been said regarding the relative efficiencies of day and night work in the other departments of the foundry, nor has it been well impressed upon the mind of the average investigator of electric steel problems that one can easily lose many times the 10-15 per cent saving in molten metal costs in the decreased efficiency of the night shifts on the molding floor, cleaning room, etc.

Claims are being made that 10 to 12 heats from cold scrap can be taken from one electric furnace in 24 hours. Possibly they can, but the furnace will have to be rebuilt at least three times each week.

These and other considerations have led to the practice, now established at Easton, of operating the foundry on day shift only, charging a good quality of steel scrap, enough pig and ore being added to keep the charge off the furnace bottom, and casting steel of around 0.20 carbon, unless otherwise specified.

The furnace plant has been operated on a one-heat-per-day basis, requiring 7 to 7½ hours to turn out its charge from the cold furnace. Power consumption at furnace transformer primary terminals has, in that case, averaged 1050 kw-hours per 2000 lb. (909 kg) steel in the ladle.

The furnace has been operated also on a two-heat-per-day and three-heat-per-day basis, when business conditions warranted. The second and third heats, having the advantage of being started off in a hot furnace, are finished in 4½ hours, at a current consumption of 630 to 640 kw-hours per ton. Even with the three heats per day, no steel is poured outside of the regular day shift. Two men start the furnace shortly after midnight, and steel is poured at 7.15 a. m., 11.45 a. m. and at 4.30 p. m. The uncertainties attaching to pouring on schedule time are not as great as they are with either open-hearth or crucible furnaces.

The load curve for the furnace here considered is smoother and of higher power-factor than the load of similar magnitude used in the shops of the Treadwell company where the products of the steel and iron foundries are machined.

Mr. Treadwell has recently sent the following additional data concerning his furnace:

| | |
|---|---|
| Average number of heats per week | 15 |
| Average weight per heat | 4600 lb. |
| Average power consumption per 2000 lb | 900 kw-hour |
| Average repair costs per 2000 lb | $2.50 |
| Average electrode costs per 2000 lb | $2.50 |
| Average weight castings made | 9 lb. |
| Ratio of cleaned castings, risers, etc., to charged weight, | 92-95 per cent |
| Ratio of finished castings to charged weight, | approximately 60 per cent |

The furnace lining is repaired after 35 heats.

Mr. Treadwell is a firm believer in pouring extremely hot steels, and this fact is reflected in the high maintenance costs and in a rather high power-consumption.

A similar furnace, of which Mr. Hansen has accurate records, shows costs as follows:

| | |
|---|---|
| Power consumption per 2000 lb | 725 kw-hour |
| Repair costs per 2000 lb | $1.30 |
| Electrode costs per 2000 lb | $2.15 |

The latter furnace is pouring somewhat colder metal into castings of 15 lb. average weight, and repairs to the furnace lining are made after 8 to 10 weeks' operation on the same basis of fifteen heats per week. In the latter case the repair charges include upkeep of the bottom-pour ladles used, and this is believed to be also the case with Mr. Treadwell's figure.

### Electric Furnaces for Steel Making

Mr. E. B. Clark, in his paper on this subject, says that the intending user of an electric furnace wishes dependable answers to two questions:

First.—How will an electric furnace compare with some other apparatus for producing or refining steel as to quality of output and cost of operation?

Second.—Assuming the wisdom of an electric furnace installation, what is the best type of furnace, and what size of unit is proper?

The author compares the electric furnace, the crucible furnace, the Tropenas converter, and the open-hearth furnace.

The crucible furnace enables one to make accurate alloy mixtures of high quality without contamination from gases or furnace linings. Practically no refining can be done and therefore high-grade materials must be used for the mixture. By the law of supply and demand, the price of pure materials for use in crucible furnaces will be higher where the crucible process is employed to a considerable extent. The electric furnace will produce steel of the same degree of purity as a crucible furnace, and the possibility of refining in an electric furnace makes possible the use of less pure materials. This is an advantage for the electric furnace and, at the same time, an advantage for the crucible furnace, because the demand for the high grade materials necessary in the crucible process is reduced by each additional electric furnace installation and therefore the price of the charge for the crucible furnace is reduced. This is especially true as applied to the small crucible furnaces used in foundry practice, which require low-phosphorus steel punchings for their successful operation.

The small Bessemer converter, or Tropenas vessel, is capable of producing hot steel in small units quickly. It does not permit of refining, however, and therefore, necessitates the use of low phosphorus and low sulphur pig iron which must be pre-melted in a cupola, using high-grade coke. The losses are severe and the steel is not free from oxides and occluded gases. The electric furnace will produce steel just as hot as the small Bessemer vessel, but free from oxides and occluded gases. However the electric furnace requires scrap for charging rather than pig iron, so if only pig iron is available at commercially desirable figures, the pig must be converted into steel before charging into the electric furnace.

The open-hearth furnace will produce from pig and scrap, steel of a fairly high degree of purity and of fairly high temperature. The electric furnace will do the same thing (except that the use of a large percentage of pig is not desirable) and is capable of producing purer and hotter steel than is the open-hearth under usual operating conditions.

Summarizing these general observations, it may be said that for the alloying of steels the electric furnace offers nothing that the crucible furnace does not; for the production of a very hot steel an electric furnace offers nothing that the Bessemer converter does not; and metallurgically speaking, the electric furnace offers nothing that the open-hearth does not. It is a fact, however, and this is the important fact, that the electric furnace combines in itself certain advantages of all three of the other processes mentioned. On the other hand, it is seldom that one wishes to secure the advantages of all these other three processes combined in one.

For the electric furnace the cost of power is not of supreme importance. Experience is more important. The electric furnace is a more delicate apparatus than any of the other three furnaces mentioned. Electric furnace operation has not yet been reduced to standard practice. Melters familiar with its operation are scarce and difficult to find.

Mr. Clark then gives an account of his experience with two electric steel furnace types. One is a 1 to 1½-ton furnace of the Stassano surface-arc type, the other a 5-ton furnace of the Heroult submerged-arc type.

"To summarize our views upon the relative merits of the two types of furnaces, as based upon our own experience, I would say that we have found the surface-arc type to be a much better furnace than its critics would have one believe. On the other hand, we have found the submerged-arc type better for our purposes because of its larger capacity and lower cost of operation. It would not be fair, however, to ascribe the lower costs entirely to its type, for the capacity of a unit certainly has much to do with the lower cost. Where a foundry is, like ours, entirely dependent for its supply of hot metal upon the electric furnace, this type is better by reason of less necessity for lining repairs."

"In conclusion, I wish to reiterate my statement that an intending user of an electric furnace may expect to learn much more about the furnace by his experience after he gets it than by the statements of someone who wishes to sell him a furnace."

### Discussion on Electric Steel

The two papers by Mr. Hansen and Mr. Clark elicited quite a lively discussion.

Mr. H. D. Hibbard said the two papers are valuable as an account of actual practice. He thought that operators of electric steel furnaces often use too high a temperature.

Mr. Ernest Humbert protested against the concluding remarks in Mr. Clark's paper as a reflection on sellers of electric furnaces. Electric-furnace steel is fully equal to the best crucible steel. While good steel castings can be made in crucibles, it is not possible to make them low in carbon. As to the scarcity of skilled electric melters, he had himself trained quite a number of men reliably in a short time in electric-furnace operation. It takes quite some time to produce a good open-hearth melter. He thought that an advantage of the Heroult type over the Stassano type is that in the former the roof is subjected to less heat by radiation.

Dr. K. G. Frank gave figures on the progress of the electric steel furnace in Europe, especially in Germany and Austria, which has been much more rapid and satisfactory than in this country. He thought American steel makers had not attacked the electric steel furnace problems with the same thoroughness and attention to detail.

Mr. Henry Hess spoke of his satisfactory experience with a Stassano furnace in making steel castings during several months and, contrary to Mr. Humbert's statement, they have had no trouble at all with their magnesite roof.

Mr. C. A. Hansen thought that Mr. Clark after having operated a Stassano furnace had applied his experience obtained with the latter to the operation of a Heroult furnace. This is a mistake as there is an essential difference between the two types. A characteristic feature of the Stassano furnace is the independence of slag. The Heroult furnace is not independent of the slag and it is important to avoid fluctuations of power supply.

Dr. J. W. Richards said that electric-furnace roofs are not always of silica as had been intimated. Stassano uses a magnesite roof. Aluminium nitride may also be considered as a suitable material. He agreed with Dr. Frank that the more rapid progress of the electric furnace in Europe is due to the greater patience exercised there.

Dr. C. G. Schluederberg said that at a recent visit to the Latrobe Steel Castings Company he had seen several runs with manganese steel in a Heroult furnace and had been impressed with the very uniform load curve.

Mr. C. A. Hansen remarked that crucible steel castings are not all now what they used to be. They are not always dead melted. The electric furnace has one important advantage for large production, that is the possibility of knowing exactly what you are pouring before you pour. With converter and crucible steel castings you must rely on guess work and this results in nonuniform metal. The main thing in a new electric-furnace plant is to establish a practice. The trouble is now that high-priced men accept positions as electric-furnace melters at a low salary simply to get the experience, and when they get it they leave and the training of a new melter has to begin all over again.

Mr. E. L. Crosby said that the Detroit Edison Company had made a special rate for electric steel at ¾ cent per kw-hour or less, according to the hours in which the current is used.

Mr. F. A. Lidbury remarked the electric steel furnace was an example of the possibility of using the electric energy of central stations during off-peak hours.

Mr. C. A. Hansen said from his experience that with one heat a day it cost $80 per ton to make a ½-ton heat and $27 per ton to make a 15-ton heat, while with two heats per day the cost for a ½-ton heat is $60 per ton and $19 per ton for a 15-ton heat.

Mr. R. Turnbull thought the figures for the ½-ton heats were high. Mr. W. McA. Johnson suggested Mr. Hansen's salary might be in the overhead charges.

Mr. E. F. Cone emphasized the physical and chemical superiority of electric steel castings, due to the greater refining possibilities of the electric furnace. The chemical purity is greater, the tensile strength and elastic ratio are improved, and not only the static but the dynamic properties of the steel are better.

Mr. Hess thought that steels of exactly the same composition would have the same properties and that it would not matter whether the heat had been applied electrically or otherwise.

Mr. Hansen said that comparative tests of electric steel and open-hearth steel at Schenectady had shown no essential difference in properties.

Dr. Richards stated that the refining action of the electric steel furnace must result in superior castings and Mr. Cone added that it was self-evident that the purer a steel the better its qualities, and that the higher purity of electric furnace steel could not be questioned.

Mr. Wm. D. Mainwaring said that steel must be mixed thoroughly and the time factor must be taken into consideration. In his 15 years' experience in steel making with all kinds of furnaces he had seen some of the poorest steel made in electric furnaces and had seen some of the best made in that furnace. It is necessary to work steel right in all kinds of furnaces.

Mr. Hibbard thought that the hearth on which the steel is made should be taken into consideration. In the crucible it is graphite, in the open-hearth iron oxide, while the electric furnace has a basic bottom.

### Metallurgy of Zinc

The following two papers were read by title only as they had already been read before the New York Section of the Society; long abstracts of the same were given on pages 677 and 678 of our Vol. XI (December, 1913):

"Improvements in the Metallurgy of Zinc," by G. C. Stone.

"Electric Zinc Smelting," by W. R. Ingalls.

Contrary to expectations there was no discussion.

### Advantages of Southeastern Alaska for Hydroelectrochemical Industries

An article by Mr. W. P. Lass called attention to the natural resources of Southeastern Alaska for that class of industry which requires cheap hydroelectric power. The unsettled policy of the Government regarding the exploitation of Alaska has hindered development in that country; but more recently the Government's attitude is more clearly defined. It is impossible to get perpetual title to water rights, but 50-year permits for the use of water, subject to renewal, may be obtained by the payment of nominal fees not exceeding $1 per horsepower year.

Southeastern Alaska presents a network of navigable bays and inlets with shores rising to an altitude of two or three thousand feet. Lakes situated high in the mountains afford an easy means of conserving precipitation and equalizing flow.

At the present time only a very few of the available waterpower sites have been developed. One of these, the Speel River project, can develop all-year power to the extent of 1000 hp. The cost of generating is estimated at not to exceed $5 per horsepower year, and the cost of installation at less than $50 per horsepower.

The country has economic deposits of such raw materials as limestone, marble, gypsum, silica and pyrites. There is also high-grade semi-bituminous and anthracite coal, as well as producing oil wells and a refinery. There are known deposits of iron ores in Alaska, and the electric production of pig iron is a possible industry on account of the availability of cheap power and the abundance of charcoal.

The author believes that Alaska offers the same advantages as Norway for the establishment of electrochemical industries, with the exception of the cost of labor, which is $3 to $4 per day. Among the manufactures which the author considers possible in Alaska are electric smelting of iron and non-ferrous minerals, the production of sulphuric and nitric acids to be used in the manufacture of wood pulp, paper, and phosphate fertilizers. Cyanide and powder are also in demand and can be manufactured in Alaska for use throughout the West.

Another possible industry is the manufacture of potash salts from kelp.

### Leaching Copper Ores at Chuquicamata, Chile

The feature of the Saturday morning session held in Earl Hall, Columbia University, was an illustrated lecture by Mr. **E. A. Cappelen Smith**, consulting engineer with M. Guggenheim Sons, on the progress of experimental work in the treatment of oxidized copper ores from Chuquicamata, Chile. The investigations have been carried out under the direction of Mr. Smith during the past year on a large scale for the purpose of determining the metallurgical details of the 10,000-tons-a-day plant to be erected in Chile.

E. A. CAPPELEN SMITH

In view of the importance of this lecture we print it in full on page 291 of this issue and also comment on it in our editorial pages.

Mr. Smith exhibited the fused magnetite electrodes used as anodes and originally invented by the German Griesheim Company for their use in their cells for electrolysis of brine.

The lecture was discussed by Messrs. Richards, Addicks and Lidbury.

### The Hydroelectrolytic Treatment of Copper Ores

This paper by Mr. **Robert R. Goodrich** gives a brief summary of hydro-electrometallurgical copper processes and a review of the literature on that subject. The author classifies the hydro-electrometallurgical process into two groups: First, purely chemical methods such as alkali, sulphite, sulphate and chloride processes; and second, electrolytic methods such as sulphate and chloride processes. The paper consists mainly of brief descriptions of different processes according to above classification.

### Leaching of Copper Tailings

A paper by Dr. **Rudolf Gahl** gives the results of some leaching tests made at Morenci, Ariz., in connection with the concentrating plant of the Detroit Copper Company. The author calls attention to the changing sentiment among the engineers regarding the feasibility of leaching copper ores. The water-concentration processes have not given satisfactory recoveries of metal, particularly in those cases where there is a mixture of sulphide and oxidized copper minerals.

The loss of the latter is very high, particularly in slime tailings.

The author advocates the counter-current continuous decantation process, as developed in the cyanide industry, as the best method of leaching and washing copper slimes.

The work at Morenci resulted in the recovery of 60 per cent of the copper contained in the slime tailings, this recovery representing the copper existing in the oxidized state. A higher extraction could have been obtained by using ferric sulphate in connection with sulphuric acid.

The probable operating costs of a leaching plant for slime tailings were calculated on the basis of the experiments, with a certain margin for safety. They are represented below. The tailings slime being ordinarily a waste-product was considered not to cost anything.

Probable Cost of Leaching Tailings Slime per Pound of Copper Delivered at New York

| | |
|---|---|
| 3.50 lb. acid, at $10 per ton $H_2SO_4$ | 1.75c. |
| 1.50 lb. of scrap iron, at $19 per ton | 1.43c. |
| Power | 0.25c. |
| Labor and repairs | 1.00c. |
| Smelting, refining, transportation of Cu, including losses in smelting, etc | 2.00c. |
| Interest and depreciation of plant | 1.00c. |
| Total | 7.43c. |

The figures are based on conditions prevailing at Morenci, Ariz., where the tests were made. Owing to the location of this mining camp freight rates are rather high.

Since making the leaching tests the flotation process has been applied to the same material with considerable success in saving the sulphide portion. The author concludes, therefore, that for certain classes of copper ores the combination of a flotation and a leaching process consitutes a form of treatment that would be difficult to surpass.

### Metal Inventory in an Electrolytic Copper Refinery

A paper by Mr. **Ralph W. Deacon** giving in complete detail the methods used in an operating plant for a number of years, in taking regular inventories of metal. The taking of the inventory is divided into sections, each operating department accounting for all metal on hand at the inventory moment or "cut off."

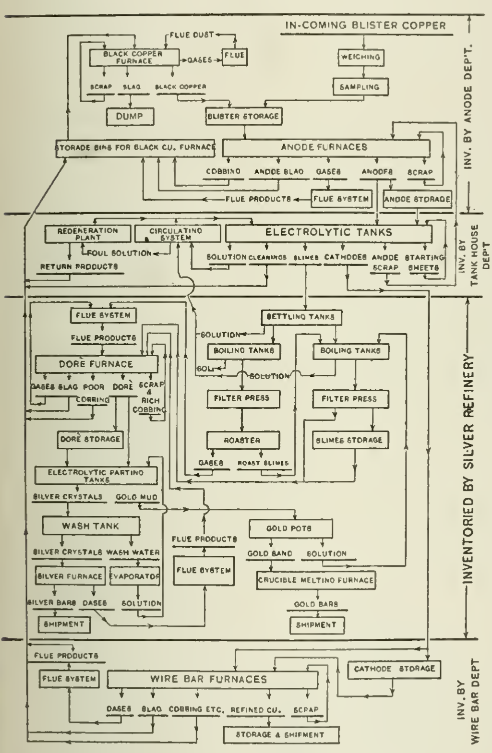
"Cut offs are made between each department and between sub-units within each department, and for materials going in each direction, and each department or sub-unit is held responsible for the proper handling of the 'cut off' of both incoming and outgoing material, with especial emphasis placed on the incoming 'cut off.' That is, a department is not relieved of the responsibility of seeing that the 'cut off' on outgoing materials is correct, but the initiative in this respect is expected to be taken by the department receiving the material, i. e., the incoming 'cut off.' This has so worked out that any trouble due to mixup in proper 'cut offs' is entirely unknown."

There are four separate inventories grouped, as shown on page 339. "In general the anode department accounts for all metals between the stages of arrival at the plant and delivery in anode form to the tank house. The latter then accounts from this point to that of delivery of cathode copper to slimes. The wire-bar department accounts from the stage of cathodes received to refined copper shipped, and the silver refining department, from slimes received to fine gold and silver shipped."

### Electrolytic Zinc

A paper by Professor Jos. W. Richards on the electrolytic deposition of zinc was read by title as it has been already presented before the New York Section of the Society. It is a review of a recent lecture by Dr. Victor Engelhardt on the subject, with critical remarks by the author.

FLOW SHEET OF ELECTROLYTIC COPPER REFINERY



DEPARTMENT INVENTORY OF COPPER REFINERY

### Addition Agents in the Deposition of Zinc from Zinc Sulphate Solution

A paper by Messrs. O. P. Watts and A. C. Shape gives the results of experiments with forty-two different organic substances in a zinc-plating solution.

The electrolyte was made by adding an excess of zinc to dilute sulphuric acid. The solution had an acid reaction and contained 25 per cent of $ZnSO_4.7H_2O$. The amount of organic substance added was 1 gram per liter. The solutions were electrolyzed for two hours at about 22 deg. C., with a zinc anode and an iron cathode, at a current density of about 10 amperes per square foot (1.1 amperes per sq. dm.). For comparison, the well-known Meaker galvanizing solution was electrolyzed under similar conditions. The majority of the substances added had an injurious rather than a beneficial effect upon the deposit. The most common defect was the production of vertical grooves or striations.

The general result of these preliminary experiments was the discovery of three promising addition agents for the deposition of zinc from a solution of zinc sulphate, namely, eikonogen, pyrogallol and betanaphthol.

### Electrodeposition of Cadmium

Two papers, by Professor Frank C. Mathers, and Mr. Hugh M. Marble, of Indiana University, deal with the electrodeposition of cadmium.

The first paper gives a review of the existing literature on the electrodeposition of cadmium and is divided into four chapters, dealing with cadmium salts of inorganic acids, ammoniacal solutions, cadmium salts of organic acids, commercial plating and refining respectively. In almost all cases crystalline rough deposits were obtained.

In the second paper the authors give the results of their own original experimental work in which an attempt was made to determine what salts of cadmium are best suited for giving smooth, non-crystalline deposits. Baths containing equivalent weights of the different salts of cadmium were electrolyzed under the same conditions. The cathodes from the ammoniacal and the alkaline tartrate baths were hopelessly spongy. The deposits from the acetate, bromide, iodide, sulphate, phosphate and chloride solutions were rough and crystalline. Many experiments were tried with the chloride solutions. A bath containing 4 per cent cadmium as the chloride, 10 per cent ammonium chloride, 5 per cent hydrochloric acid (by volume) and 0.1 per cent peptone gave a fairly smooth, finely crystalline deposit. A bath of the same composition as that just given, with the addition of 10 per cent ferric chloride, gave a much better deposit. Manganese, aluminum or chromium chlorides did not improve the deposit in the same way that the iron did. None of these deposits were equal to those described below. In the few experiments that were tried with the bromide and iodide solutions, the deposits were more crystalline and rough than with the chloride baths.

Fluoride, fluosilicate, fluoborate or perchlorate solutions containing 4 per cent cadmium, with 0.5-5 per cent free acid and 0.2 gm. peptone, glue or phloridizin, or 4 drops of clove oil, gave excellent, smooth deposits. Not all of these addition substances were tried with all of the above cadmium salts, but in all cases where they were tried excellent deposits were obtained. Sometimes spongy places or spots were formed upon the cathodes. Some rough projections also gradually formed on some of the cathodes. It is thought that these rough places were produced by particles of slime, which became detached from the anodes in spite of the wrappings of filter paper. Amalgamation of the anodes completely prevented slime from becoming detached, but this scheme was tried only in the quantitative experiments.

These experiments again demonstrate the value of "addition agents," since smooth deposits of cadmium could not be obtained without their use. The same addition substances—clove oil, glue, peptone and phloridizin—which were found to give good lead deposits are the only valuable ones for cadmium deposition.

Cadmium is much more difficult to obtain in a smooth condition than lead.

There was a gradual loss of free acid in the baths, due to chemical solution of the anode. This had little effect upon the deposits, since only a little free acid is required in the solutions.

### Electrodeposition of Nickel

A paper by **Dr. C. W. Bennett, Mr. H. C. Kenny** and **Mr. R. P. Duggliss**, of Cornell University, on the electrodeposition of nickel reaches the following results:

A good deposit of nickel may be obtained from the double sulphate if the solution at the surface of the cathode is kept alkaline.

The efficiency is dependent upon the degree of alkalinity of the cathode film.

The efficiency can be started high and maintained high by adding a definite amount of ammonium hydroxide to the solution.

The alkaline solution film at the cathode may be disturbed and the efficiency of deposition decreased by stirring the solution vigorously.

Since alkalinity is necessary for good efficiency, it is very probable that in acid solutions nickel is deposited only when impoverishment of the hydrogen ions has caused the solution to become alkaline and given the conditions under which nickel may deposit.

The iron content of a deposit formed on a rotating cathode is greater than that formed on a stationary electrode. This may be due to mechanical occlusions.

The iron content of the anode does not materially affect the efficiency.

### Electrolytic Deposition of Brass

A paper by **Dr. C. W. Bennett** and **Mr. A. W. Davison**, of Cornell University, on the electrolytic deposition of brass on a rotating cathode, reaches the following conclusions:

Measurements were made of the voltages required to deposit copper and zinc from a number of solutions with rotating cathodes, the voltages being measured against an oxygen electrode. Those solutions giving similar curves were studied with a view to obtaining a good deposit of brass. A brass was not obtained in any case, except from the cyanide solution.

The deposition of brass from cyanide solution is probably due to two factors: First, the tendency for the potentials of copper and zinc to become the same in the cyanide solution, and, second, the increase in the potential of the more noble metal by impoverishment. The latter factor is practically eliminated by using the rapidly rotating cathode.

A satisfactory brass has not been deposited from the cyanide solution on the rotating cathode. The brittleness of the alloy is probably due to occluded impurities. Hydrogen was removed from the alloy by heating in alkali. The disturbing factor probably arises from the cyanide itself, which it seems impossible to eliminate.

The effect of impoverishment has been shown by showing that a brass may be obtained up to a limiting speed of rotation of the cathode, beyond which zinc alone is deposited.

The metal ratio of copper to zinc in solutions for the deposition of a brass varies not only with variations of free cyanide, but also with the rate of rotation of the cathode.

### New Method for the Determination of Free Cyanide In Electroplating Solutions

A paper by **Mr. Gustave E. F. Lundell** proposes a new method for the determination of free cyanide.

"Briefly stated, the new method consists in titrating an ammoniacal cyanide solution containing a small quantity of dimethyl glyoxime, with standard nickel-ammonium sulphate solution until a permanent red precipitate is produced. The reactions involved are expressed by the equations:

$$NiSO_4 + 4KCN = K_2Ni(CN)_4 + K_2SO_4$$
$$NiSO_4 + 2C_4H_8N_2O_2 = Ni(C_4H_7N_2O_2)_2 + H_2SO_4$$
$$H_2SO_4 + 2NH_4OH = (NH_4)_2SO_4 + H_2O$$

"No permanent red precipitate of nickel dimethyl glyoxime is formed until all of the free cyanide has been used up in the reaction expressed by the first equation. Free sulphuric acid hinders the precipitation of nickel dimethyl glyoxime, hence the ammoniacal cyanide solution."

The solutions required are a standard solution containing 15.3 grams of nickel-ammonium sulphate, in water containing 5 cc. concentrated sulphuric acid, diluted to 1 liter and a dimethyl glyoxime solution containing 8.9 grams of dimethyl glyoxime in 1 liter of 95 per cent alcohol.

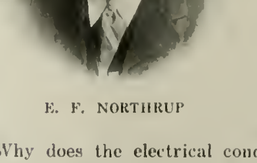
The method of analysis is as follows: A measured volume of the electroplating solution is diluted to 100 cc., treated with 1 cc. of ammonium hydroxide, 1 cc. of the dimethyl glyoxime solution, and then titrated to a permanent red precipitate with the standard nickel-ammonium sulphate solution. The color play toward the end of the reaction resembles that seen in the titration of an alkaline methyl-orange solution with an acid solution. For the sake of accuracy, and also convenience, the volume of electroplating solution taken should contain from 0.2 to 0.5 gram of free cyanide.

The author states that the new method is more rapid and accurate than other methods and has greater freedom from interferences.

### Electric Conduction at High Temperatures

The session of Saturday afternoon, held in the lecture room of the School of Mines, Columbia University, was opened by a lecture, illustrated by many lantern slides, by **Dr. Edwin F. Northrup**, of Princeton University, on "Electric Conduction at High Temperature and How to Measure It."

The older physics recognized matter and energy as the two objective realities but the newer physics adds electricity as a third objective reality. The transference from one point in space to another of unelectrified matter, or of electromagnetic energy forms no part of the problem of electric conduction which is confined to the transference of electricity.



E. F. NORTHRUP

The problem of electricity must answer the two questions: (a) Why do different materials have a different electrical conductivity at the same temperature? and (b) Why does the electrical conductivity of a given substance change when the temperature changes?

These questions can only be answered in a satisfactory way, without unwarrantable extrapolation, by examining the experimental facts of conduction over a very wide range of temperature. By far the greatest number of facts of conduction have been examined in the temperature range, 0 deg. to 100 deg. C., which is but about 2½ per cent of the temperature range which has been experimentally realized.

A slide showing the temperature scale was shown, which revealed the restricted range of temperature to which most scientific inquiries are confined, and it was pointed out that nature grows less complex as we depart in either direction from the temperature at which organic life exists; that by studying conduction at high temperatures many complexities become eliminated which permits us to better understand electrical conduction at temperatures where we use it; and that the sharp distinction we are accustomed to make between conductors and insulators only belongs properly to the lower half of the highest temperature range obtainable—from 0 deg. to 4000 deg. absolute.

The leading facts of conduction now known were summarized. The work of Onnes, who showed that some pure metals have infinite conductivity at about 4 deg. absolute, were referred to and his curves were shown. At low temperatures the insulators have infinite resistivity while the alloys are intermediate in resistivity.

At elevated temperatures comparatively few facts are known regarding conduction on account of the experimental difficulties heretofore met with in making accurate measurements. These experimental difficulties being in large part now removed, we are able to show the characteristics of the conduction of nonmetallic solids and the conduction of metals in the solid and molten state to temperatures as high as 1500 deg. C.

Slides were shown (six made by Dr. Sommerville and ten by Dr. Northrup) giving curves which accurately express the variation of resistivity with temperature of several oxides of the metals and of the pure metals Na, K, Hg, Cd, Pb, Zn, Sn, Bi, Sb, Cu, Al, Au, and of the alloys Na+K, and brass. It was pointed out that all of these metals and alloys with the exception of bismuth and antimony, suddenly increase in resistance in passing from the solid to the liquid state.

In general the ratio of the resistivity just after fusion to the resistivity just before fusion, is roughly 2.

This ratio for bismuth is 0.478 and for antimony about 0.75. Both of these metals contract on liquifying.

With the exception of zinc, cadmium and antimony, the increase in resistance with temperature of the metals in the molten state is very nearly linear. In the case of gold and copper, which were examined to over 1450 deg. C., the increase in the molten state is exactly linear.

Methods for making these measurements were then considered under the headings—Methods of producing the temperature, of measuring the temperature and of making suitable holders for refractory materials at temperatures where everything conducts and for metals in the molten state. A large and small model of the new "Northrup high-temperature furnace," in which platinum may be melted, were exhibited and their construction explained and uses demonstrated. This has been described in detail in this journal. A slide was shown of the veteran furnace in which many measurements were made to temperatures as high as 1600 deg. C. and under.

Slides were shown of a new device, called a "cascade attachment," which may be quickly placed in the large type furnace and by means of which a temperature may be readily obtained which will melt tungsten, or even vaporize carbon. (See also the article by Dr. Northrup on this subject on page 305 of this issue). Any lower temperature can also, by its means be obtained and held. It was pointed out, that because of the black-body conditions obtained and the fact that the heated zone can be directly looked into without an intervening window of unknown light-absorbing power, radiation at temperatures blending into that of the arc may be conveniently studied.

A summary of the facts of conduction at high temperatures was given and a chart shown which summarized the special characteristics of the metals. The interesting relation was brought out that for six of the metals, for which data have been obtained, the ratio of the coefficient of resistance to the coefficient of cubical expansion of the metal when in the molten state, is approximately constant; that this holds true for potassium and tin; though the former has ten times the expansion of the latter.

Suggestions were then given for investigations on the subject of conduction which are important for the future. The most important of these suggestions being that the cubical expansion coefficients of molten metals should be determined and that the resistivity should be studied of metallic vapors when near their critical temperature and pressure. The speaker expressed his belief that we do not yet know enough facts of electric conduction and related physical properties over a wide range of temperature to make it possible to formulate a satisfactory theory of conduction and that present theories are certainly inadequate to explain the facts of conduction as they have been observed at the low temperatures at which Onnes worked, to the temperature of 1500 deg. C., at which accurate data for some of the metals have been obtained.

### Electric Properties of Silver Sulphide

Mr. F. A. J. Fitz Gerald, of The Fitz Gerald Laboratories, Niagara Falls, N. Y., followed with a very interesting paper, entitled "Laboratory Notes on Some Electrical Properties of Silver Sulphide," and illustrated by lantern slides and some pretty experiments. The study of the electrical properties of silver sulphide was undertaken by the author in connection with the commercial development of an automatic fire alarm invented by Mr. E. Garretson.

The conclusions of Mr. Fitz Gerald's paper are as follows:

Silver sulphide is a solid electrolyte well worthy of study, since it lends itself admirably to experiments having for their object research on the properties of electrolytes of this class.

The temperature-resistance curve of silver sulphide shows a critical point at a certain temperature, but this is not the same on the heating and cooling curves.

The temperature-resistance curve of silver sulphide is strongly affected by impurities. Thus pure silver sulphide gives a critical point with rising temperature at 170 deg., sulphide from an alloy containing 0.5 per cent copper has a critical temperature of 163 deg., and that made from the 7.5 per cent allow a critical temperature of 104 deg. In this relation it is interesting to note that Northrup has found a critical temperature for alundum at 1100 deg.

Silver-silver sulphide and copper-silver sulphide form thermoelectric couples, the effect of which must be looked for in experimental work on silver sulphide.

Even very slight chemical reduction in a mass of silver sulphide has a great effect on its electrical resistivity.

Lack of homogeneity in the sulphide made from silver-copper alloy has an important influence on its electrical properties. The resistivity is greatly affected, and probably also other characteristics such as the thermoelectric and rectifying effects. Much of the experimental work on this point has not been mentioned because it is of too incomplete a character, but the observations made are such as to warrant a warning. This would probably explain certain anomalies which may be found in the case of mixed sulphides. These anomalies are comparable to the case of alloys where there may be a "false resistance" due to thermoelectric effects, as pointed out by J. J. Thomson.

Electrolysis may occur in a Cu — $Ag_2S + Cu_2S$ — Cu cell in a 25-cycle A.C. circuit, with the result that the cell is eventually short-circuited. On the other hand, if silver electrodes are used the cell is not short-circuited.

Electrolysis in the Cu — $Ag_2S + Cu_2S$ — Cu cell is probably due to a persistent rectifying effect. This rectifying effect is very marked in a cell where one copper electrode is coated with cupric oxide.

A rectifying effect may also be shown with an Ag — $Ag_2S + Cu_2S$ — Ag cell, but after being in an A.C. circuit for some time this disappears.

In the Ag — $Ag_2S + Cu_2S$ — Ag cell showing a rectifying effect there is a critical temperature at which this disappears on heating, and a different critical temperature at which it reappears on cooling. These critical temperatures may be correlated with the critical points of the temperature-resistance curves. Study of this phenomenon might throw some light on the nature of conduction in solid compounds, whether this is electrolytic or electronic or both.

### Polarization Single Potentials

A paper by **Mr. Claude N. Hitchcock** gives an account of an investigation carried out at the University of Wisconsin with reference to a former experiment of Dr. J. W. Richards, who obtained decomposition of water at an impressed e.m.f. of only 1.15 volts, instead of 1.67 volts, the generally accepted value of the decomposition voltage of water. This result had been obtained by the use of platinum electrodes differing greatly in size. The present author's investigation was undertaken for the purpose of determining the potential at each electrode in such cases of decomposition of electrolytes below the normal decomposition point.

The conclusions reached are as follows:

Decomposition of water can be accomplished at any voltage with platinum electrodes, provided the latter are of the proper size.

The oxygen normally present in laboratory reagents is sufficient to produce marked depolarization at the cathode.

The single potential of each electrode so depends on that of the other that any change in one, due to disturbing influences, is counteracted by such a change in the other that, below the decomposition point, the sum of the separate electrode polarization equals the total polarization, and this in turn equals (very nearly) the impressed electromotive force.

Any desired current may be passed through an aqueous solution of sulphuric or hydrochloric acid without causing evolution of gas, provided the electrodes are made large enough.

The evolution of gas at the electrodes depends on the total current density minus that part of the current density neutralized by the action of depolarizing agents.

### Determination of Free Energy

Dr. Reinhard Beutner, of the Rockefeller Institute of Medical Research, New York City, presented a paper on a "new cell arrangement for direct determination of free energy." This paper gives the results of a continuation of the researches which the author has described in former valuable papers before the society.

In his present paper it is shown how galvanic elements can be arranged so as to measure, without transfer potential, the free energy of reactions between solid salts and metals or between solid salts alone. These cells are mostly characterized by containing solid salts in the path of the current.

If two reacting constituents are present in mutual admixture, the reaction can no longer be treated as "fixed," since osmotic forces then come also into play. But even for such cases suitable galvanic cells for measuring the free energy are described. To these belong, for instance, the formation of salt hydrates, in which it is almost always found that the resulting salt hydrate is considerably soluble in water, and in consequence a fluid mixture of salt hydrate and water enters into the reaction.

Further, new electrometric methods were given for chemical reactions of the kind described, in which the reacting constituents were present diluted by indifferent bodies. To such belong especially such reactions in which salts take part in practically completely dissociated dilute solutions. It could be shown in what way cells could be arranged for the measurement of reactions, avoiding the diffusion potentials, as, for instance, the reactions in the Bredig-Knüpffer cell.

### Railway Track Cell

The paper by **Mr. E. L. Marshall**, of the National Carbon Company, Cleveland, Ohio, described a new cell of the wet type which has been developed within the last ten years for service in railway signalling Its predecessor in the same field was the Daniell gravity cell.

The paper describes the general electrical equipment for automatic block signalling and shows that a cell for the track circuit must fulfil the following requirements: low current on short circuit, constant voltage on closed circuit, large capacity, small fluctuations due to variations in temperature.

The Lalande type of cell was selected to develop a cell of this kind. It is a single-fluid cell with a zinc anode, a cathode of copper oxide and an electrolyte of caustic soda. There had already been perfected a Lalande cell with a low internal resistance and consequently a high amperage on short-circuit. But for the present purpose a high internal resistance was required.

To get a high internal resistance in a Lalande cell use was first made of a perforated porcelain plate placed between the zinc anode and copper oxide cathode. But a more efficient cell was later developed in form of the Columbia track cell. The high internal resistance is obtained in this cell by merely separating the two electrodes a long distance apart in the electrolyte, no added piece being used for the purpose. The construction of the cell is described in some detail and its advantages are pointed out.

### Experiments on White Lead

A paper by **Mr. R. Stuart Owens** gives the results of experiments undertaken to determine in what way and to what extent the character of precipitated white lead is affected by the conditions of precipitation.

Among other experiments the author produced white lead electrolytically on a laboratory scale according to data obtained from the patents of Woltereck and Luckow. The experiments proved that these two electrolytic methods are not run under conditions which give the best precipitate of white lead.

### Electrolytic Iron

A paper by **Dr. Oliver W. Storey**, of the University of Wisconsin, gives the results of a "microscopic study of electrolytic iron," prepared by the refining process of C. F. Burgess. The paper is illustrated by 48 microphotographs.

The results of the study of heated electrolytic iron are summed up as follows:

No change in structure of electrolytic iron could be determined at temperatures below the $A_3$ range.

A fine deposit is more readily changed to the grain structure than a coarse deposit.

With a short heating above the $A_3$ range the fine deposit is transformed into a fine grain structure, while a coarse deposit becomes coarse grained.

The coarse grains resulting from a coarse deposit may be broken down into smaller grains by long annealing at the $Ac_3$ point or by heating to 1000 deg. or higher.

The grain structure resulting from a fine structure is always finer than that resulting from a coarse deposit.

The grains of electrolytic iron do not grow appreciably at 1150 deg.

The microstructure of fused electrolytic iron was next studied and is illustrated by microphotographs.

Rolled electrolytic iron shows the structure of clean furite.

## The Effect of Addition Agents in the Electrodeposition of Iron

A paper by Messrs. **O. P. Watts** and **N. H. Li** gives the results of experiments on various addition agents in the electrodeposition of iron.

Previous experience in refining iron had shown that, while an electrolyte containing only chlorides gave a much smoother deposit than one consisting of the sulphates of iron and ammonia, the iron produced rusted so badly after removal from the electrolyte that a pure chloride electrolyte was not considered practical.

It was found, however, that the admixture of some chloride with the sulphate electrolyte improved the smoothness of the deposit without causing excessive rusting of the iron produced.

The electrolyte chosen as a basis for the addition of various substances consisted of 150 grams crystallized ferrous sulphate ($FeSO_4.7H_2O$) and 75 grams ferrous chloride ($FeCl_2.4H_2O$) per liter, and had a specific gravity of 1.125 at 20 deg. C.

The objectionable features of electrolytic deposits of iron are a roughness which increases with the thickness of the deposit, and a tendency to form vertical grooves or striations. The color of the electrolyte at the end of the test was closely related to the quality of metal produced. A yellowish-green electrolyte almost invariably gave clean metal of a fine color, even though it might be too badly pitted to allow of the practical use of that particular electrolyte. A dark electrolyte fouled by much green precipitate usually yielded very bad-looking metal.

The experiments show that ammonium oxalate and formin are capable of improving upon the smoothness and satisfactory deposits given by the original electrolyte.

* * *

The following is a complete alphabetical list of those who registered at the meeting; where no address is given, New York City is understood:

Paul O. Abbé, Lawrence Addicks; Chas. H. Aldrich, Perth Amboy, N. J.; R. J. Alexander; H. I. Allen, Wilmington, Del.; C. Arick, East Orange, N. J.; Mr. and Mrs. W. C. Arsen, Schenectady, N. Y.; Dr. and Mrs. L. H. Baekeland, Yonkers, N. Y.; D. K. Bachofner, Irvington, N. J.; T. F. Baily, Alliance, O.; H. A. Baker, R. L. Baldwin, A. Barnett; Wilder D Bancroft, Ithaca, N. Y.; Mr. and Mrs. Chas. Baskerville, E. A. Beck, E. H. Bedell, V. A. Belcher; C. W. Bennett, Ithaca, N. Y.; R. Beutner, D. D. Bergoheimer, Wm. Bjorkstedt; A. Blaicher, Newark, N. J.; W. F. Bleecker, Canonsburg, Pa.; Walker Bowman, Dudley Boyd, Jr., State College, Pa.; M. Brasell, Perth Amboy, N. J.; A. A. Breneman, Mrs. A. E. Brisben, R. D. Bricknell, Mrs. W. E. Brisben; C. O. Brown, Pittsburgh, Pa.; C. B. de Browne, D. H. Browne; J. K. Bryan, Perth Amboy, N. J.; C. L. Bryden, Scranton, Pa.; J. A. Brundige; M. H. Burnett, Waterbury, Conn.; F. A. Butterick; A. S. Callen, Philadelphia; H. G. Cannon, Keokuk, Ia.; Carmichael, Boston, Mass.; H. R. Carveth, Niagara Falls, N. Y.; Dr. Margaret A. Cleaves, C. C. Coates, Jesse Coates, Lynn, Mass.; H. B. Coho; E. A. Colby, Newark, N. J.; Daniel S. Collins; W. W. Colguhom Zanbridge Wells, England E. F. Cone, H. R. Connell Pittsburgh, Pa.; Mr. and Mrs. Wm. A. Cowan; Mr. and Mrs. A. H. Cowles, Sewaren, N. J.; J. S Crider, Cleveland O., Ed. L. Crosby, Detroit, Mich.; T. E. Crossman; N. J. Cummings, Haskell, N. J.; H. M. Cushing, Buffalo, N. Y.; N. E. Dabolt, Mt. Vernon, N. Y.; A. W. Davison, Ithaca, N. Y.; L. C. Diefahl, Cleveland, O.; Wm. H. Doering, Philadelphia, Pa.; C. A. Doremus, J. V. N. Dorr, Mrs. G. D. Dorsey; R. G. Dorsey, Dayton, O.; James Douglas J. Dunwald, Perth Amboy, N. J.; A. S. Dwight; W. Dyrssen, Bethlehem, Pa.; Charlton Ellis, Montclair, N. J.; O. A. EnHolm; G. W Emanuel, Perth Amboy, N. J.; Marion Eppley, E. F. Eurich C. D. Ferguson, Wm. Ferguson; Mrs. C. G. Fink, East Orange, N. J., C. M. FitzGerald; Mr. and Mrs. F. A. J. FitzGerald, Niagara Falls, N. Y.; Mr. and Mrs. C. B. Foley, Dayton, Ohio; L. W. Fogg, State College, Pa.; O. R. Foster, C. M. Foyce, Dr. K. G. Frank; M. W. Franklin, East Orange, N. J.; Hy. E. French, Farmington, Conn.; R. H. Gaines; A. J. Ganz, Hoboken, N. J.; R. E. Gegenheimer, Waltham, Mass.; J. J. Gerety, Philadelphia, Pa.; A. E. Gibbs, Philadelphia, Pa.; H. W. Gillett, Ithaca, N. Y.; Rob. R. Goodrich, Arnold J. Guerber, Canonsburg, Pa.; John Haddow, State College, Pa.; R. L. Hallett; Fred J. Hambly, Buckingham, Quebec; Carl Hamsbuchen, Belleville, Ill.; A. V. Hansell, C. A. Hansen, Schenectady, N. Y.; H. M. Harbach, State College, Pa.; J. L. Harper, Niagara Falls, N. Y.; Leon O. Hart, Hanson, N. J.; Carl Hering, Philadelphia, Pa.; J. B. F. Herreshoff; J. B. Herreshoff, Jr., Richmond Hill, N. Y.; Henry Hess, Philadelphia, Pa.; H. L. Hess, Jr., Philadelphia, Pa.; H. D. Hibbard, Plainfield N. J.; E. F. Hicks, Philadelphia, Pa.; A. J. Hinckley, Niagara Falls, N. Y.; Allan Hirsch; Wm. G. Horsch, Newburyport, Mass.; G. A. Hulett, Princeton, N. J.; R. C. Hull; Ernest Humbert, Niagara Falls, N. Y.; W. Hummell, High Bridge, N. J.; L. D. Huntoon; Mr. and Mrs. O. Hutchins, Niagara Falls, N. Y.; R. M. Hutchinson, State College, Pa.; E. B. Jewett, Clarksburg, W. Va.; H. de Joannis, Bridgeport, Conn.; J. E. Johnson, Jr., W. McA. Johnson; Mr. and Mrs. M. C. Joyce, Arlington, N. J.; Edw. G. Keller, Perth Amboy, N J.; Mr. and Mrs. H. W. Kellogg, Niagara Falls, N. Y.; Philo Kemery, Pittsburgh, Pa.; E. F. Kern, L. J. Krom, Walter Laib, Rittman, O.; M. J. Langdon; F. C. Langenberg, Cambridge, Mass.; John Langton, Ernst Leitz; F. Austin Lidbury, Niagara Falls, N. Y.; D. M. Liddell; C. F. Limpay, Bridgeport, Conn.; P. M. Lincoln, Pittsburgh, Pa.; E. A. Lof, Schenectady, N. Y.; R. L. Lloyd; S. J. Lloyd, University, Ala.; G. E. Love; A. Lowenstein, Chicago, Ill.; F. W. Lowry, State College, Pa.; G. V. Luerssen, State College, Pa.; G. P. Lunt, Boston, Mass.; D. A. Lyon, Pittsburgh, Pa.; F. W. Manger, Jersey City, N. J.; A. S. McAllister, J. S. McClenehan; K. W. McComas, Perth Amboy, N. J.; James H. McGraw; F. Maeulen, F., Prince Bay, N. Y.; E. L. Marshall, Fremont, O.; W. W. Macon; Wm. D. Mainwaring, Cleveland, O.; Mr. and Mrs. A. B. Marion, Edw. J. K. Mason; J. A. Mathews, Syracuse, N. Y.; H. A. Mayer, Portland, Ore.; W. W. Merrill, Salisbury, Mass.; Albert Meyer, Irvington, N. J.; C. Mindeleff, Perth Amboy, N. J.; Mr. and Mrs. Geo. P. Moore, Hartford, Conn.; J. M. Muir, Paul I. Murrill; R. E. Myers, East Orange, N. J.; A. F. Nagle, N. Nikune, J. R. Noeggerat; Mr. and Mrs. E. F. Northrup, Princeton, N. J.; G. Ornstein; I. Paris, Boston, Mass.; H. C. Parmelee, Denver, Col.; Chas. L. Parsons, Washington, D. C.; J. C. Pennie, Kenneth R. Pennie, F. P. Pennington, O. M. Perry; M. Petinot, Niagara Falls, N. Y.; W. L. Raup, Perth Amboy, N. J.; Thos. T. Read; O. R. Reed, State College, Pa.; Louis Ruhe, O. H. Rucker; A. R. Rhoades, State College, Pa.; Mrs. E. F. Roeber, East Orange, N. J.; C. D. Robb, Essex Fells, N. J.; Mr. and Mrs. C. L. Robbins, Wilkes-Barre, Pa.; E. F. Roeber; G. A. Roush, South Bethlehem, Pa.; Mrs. G. A. Roush, South Bethlehem, Pa.; Joseph W. Richards, Lehigh University; C. B. Sadtler, Denver, Col.; P. G. Salom, Philadelphia, Pa.; E. M. Sargent, Niagara Falls, N. Y.; L. E. Saunders, Niagara Falls; W. M. Saunders, Providence, R. I.; C. G. Schluederberg, Pittsburgh, Pa.; D. F. Schuetz; Philip Sievering, Newark, N. J.; Alex. Smith; John A. Seede, Schenectady, N. Y.; Dyer Smith, E. A. Sappelen Smith; Tracy Smith, Waterbury, Conn.; W. F. Smith, Philadelphia, Pa.; W. O. Snelling, Pittsburgh, Pa.; J. A. Schweiger; M. Snyder, Perth Amboy, N. J.; N. W. Sothman; J. L. K. Snyder, Mamaroneck, N. Y.; Geo. E. Speim, H. N. Spicer, E. G. Spilsbury; F. A. Stamps, Niagara Falls, N. Y.; S. A. Staples; Chas. P. Steinmetz, Schenectady, N. Y.; Dr. E. R. Steinhardt, Miss L. D. Steinhardt, Bradley Stoughton, G. C. Stone, Dr. Jos. Struthers; E. R. Sutcliffe, Leigh Lanes, England; W. T. Taggart, Philadelphia, Pa.; Jokichi Takamine; John B. Taylor, Schenectady, N. Y.; A. C. Terrill, Glendale, Cal.; Mrs. A. C. Terrill, Glendale, Cal; S. A. Tucker; C. C. Turnock, State College, Pa.; E. N. Todd, Newark, N. J.; F. J. Tone, Niagara Falls, N. Y.; R. Turnbull, Welland, Ontario; K. Usui, Tokio, Japan; T. Usui, R. H. Vail; I. R. Valentine, Schenectady, N. Y.; G. D. Van Arsdale; A. Van Winkle, Newark, N. J.; C. H. Von Bauer, Douglaston, N. Y.; W. E. Volz; Mr. and Mrs. Alois Von Isakovics, Monticello, N. Y.; Mr. and Mrs. L. D. Vorce, Wyandotte, Mich.; A. L. Wacken, J. H. Ward, C. M. Wales, C. H. Wang; C. A. Weeks, Philadelphia, Pa; Harry B. Weiser, Ithaca, N. Y.; Mrs. J. R. Wettstein, Mt. Vernon, O.; Thos. F. Wettstein, Perth Amboy, N. J.; W. V. Whitney, Schenectady, N. Y.; Elliott H. Whitlock, Cleveland, O.; M. C. Whitaker; R. H. White, Niagara Falls, N. Y.; R. P. Williams, Waltham, Mass.; A. M. Williamson, Niagara Falls, N. Y.; W. W. Winship, H. C. Wirt, Roy U. Wood; W. J. Wooldridge, Pittsfield, Mass.; W. J Yabrevitch, Pittsfield, Mass.; M. A. Yurick, South Orange, N J.

---

**Iron has been produced experimentally** in the electric furnace at the foundry of the Carnegie Institute of Technology, Pittsburgh. The experiments were in charge of Mr. Frederick Crabtree, professor of metallurgy at the Institute. Raw Mesabe iron ore was converted into high-grade pig iron.

**The Senate radium hearing** before the mines and mining committee was attended by practically the same interested parties as appeared before the House committee. No new features were developed. The arguments pro and con were about the same as brought out before. Both hearings have been published and can be secured by those interested.

# Some Economic and Aesthetic Aspects of Electrochemistry*

BY E. F. ROEBER

There is beauty in electrochemistry. The late Ludwig Boltzmann once said that of all artists the mathematical physicist is nearest to the world's Creator in the simplicity, directness and economy of his methods; Boltzmann made this remark in appreciation of the work of Kirchhoff and Maxwell. But we can apply it with equal truth to the electronic theory of our own time which in the simplicity of its fundamental conceptions and in the comprehensiveness of its outlook has all the elements of pure beauty. The intellect which builds the structure of the atoms of the different chemical elements out of a positive electric nucleus in association with varying numbers of negative electrons, and makes his atoms produce the desired result, is a true creator, and his model has beauty like the visible world around us.

But more beauty is hidden in electrochemistry than the mathematical beauty of electrochemical theory. The research electrochemist who works out a new process whether it is the reduction of aluminium from its oxide, or the conversion of amorphous carbon into graphite, or the production of calcium carbide from lime and coke, or whatever else, proceeds exactly along the same methodical lines as the artist, whether he be sculptor or painter or poet. The artist must take nature as it is. But for his work he takes from nature only what his imagination tells him to be essential to the idea he has in mind. It is this selective copying of the essential from nature and this restriction to nothing but the essential that makes a work of art beautiful.

The method is exactly the same with the creative electrochemist. He cannot improve on Nature's processes and methods. All he can do is to imitate or copy Nature's processes and combine them to a certain end. But because his goal is a certain product he can select the starting materials which are essential and use nothing else, and he can select those processes which are essential and combine them into the most direct method of production, and produce only what is wanted. Artificial graphite made in the electric furnace is superior to natural graphite, because nature does not set out to make pure graphite and man can. This makes the economic value of artificial graphite; but it also makes the artificial graphite process, in the bold directness of its execution, a true work of art. Wherever a process is so designed as to reach its object in the most direct way with greatest economy, it is beautiful in the eyes of those who understand its rationale. This is broadly true and not restricted to electrochemistry; but the trained engineer's or scientist's intellectual eye is needed to see this type of beauty.

The thoughts on some particular aspects of electrochemistry which I want to submit to you for reflection tonight are of a cognate nature. They refer to the part which electrochemistry plays in the changes now going on in modern civilization in economic and æsthetic valuations. Our age is called an age of unrest and revolution. Whether we are really so much more restless than our ancestors is open to discussion and hard to decide. But that the scientific and concomitant engineering advances of the last century have brought an entirely new phase (in the phase-rule sense) into the play of human reactions which make up the history of mankind, is not open to question. That the effects of modern science and engineering go far beyond their spheres of immediate interest is undisputed. What then is the effect of electrochemistry on two fields apparently so remote as political economy and æsthetics?

To express the question concisely I borrow Friedrich Nietzsche's phrase of the revaluation of values. My subject is: How does electrochemistry bring about a revaluation of economic and æsthetic values? I have brought Nietzsche's name into this discussion for still another reason. Nietzsche's brilliant and, at first sight, extraordinarily daring attempt of a revaluation of ethical values for the sake of creating the "Uebermensch," is perhaps in the final analysis of its positive aspects nothing more than a robust reassertion of what was strong and healthy in the viewpoints and valuations of classic Greece and Rome, but has been lost in the last nineteen centuries to an exaggerated weak sentimentality. Nietzsche wanted to make restitution of this lost strength and health from classic Greece to modern civilization and thus create a new ethics. Now, it would seem that the effect of science and engineering on æsthetics is acting at present in the same direction in emphasizing the necessity of a return to the æsthetic viewpoint of classic Greece, as embodied in Socrates' view of the kinship of beauty and utility. It is for this reason that before speaking of æsthetic aspects of electrochemistry it is necessary to take up its economic aspects.

How are economic values being created by industrial electrochemistry? For this discussion Professor Karl Knies' old and well-known conception is very useful: that economic value is of three kinds—place value, time value and form value. If I may use the text-book illustration, ice in winter in the Maine woods has no economic value because there is no market for it there. Brought to New York, it gets place value, because there is a demand for it in New York. Stored and sold in summer time, it gets an additional economic value—time value. Nothing has been done to the ice itself by man. The place value has been created by transportation, the time value by storing, and as we will see later these two points are of importance for the production of economic values by electrochemistry.

But for the present let us consider the third kind of economic value—form value—that is the value created by the work done by man on the materials of nature, comprising mechanical work as well as chemical changes. Any chemical reaction produces or annihilates form values, economically speaking. But what is the distinguishing characteristic feature of the form values produced by the electrochemical industries? Let us take a few typical examples.

By the electrolysis of a solution of common salt we get caustic soda and chlorine, and we work up the latter perhaps into bleaching powder. The excess of the value of the caustic soda and bleaching powder over that of common salt is the form value produced by this process. So it is in the production of calcium carbide from lime and coke, of nitric acid and nitrates from atmospheric air and so on.

The fixation of atmospheric nitrogen, representing an extreme case, is most instructive. The raw material is atmospheric air which, as such, has no economic value at all, so that we might say that in the production of nitrate from air the economic efficiency becomes infinitely high. It sounds very well to speak of a process with an infinitely high economic efficiency, but if we stop to remember that exactly this process which is now worked with fair financial results in Norway proved a commercial failure some ten years ago in Niagara Falls, it is evident that our consideration must have been in some way so one-sided as to be misleading.

Why was fixation of atmospheric nitrogen a failure at Niagara Falls and why is it a success in Norway? Not primarily on account of the process, because the Bradley-Lovejoy process worked with about the same technical efficiency as the Birkeland-Eyde process, though the apparatus was considerably more ecomplicated. No, the decisive element which caused failure at Niagara Falls and success in Norway, is the cost of electric power which is three to five times lower in Norway than at Niagara Falls. And this brings us right to the root of the whole matter.

---

*Presidential address delivered before the American Electrochemical Society on April 16, 1914.

In discussing the economic value of some electrochemical products we have so far, in a one-sided way, compared only the value of the starting materials and of the end products; but we have entirely neglected the fact that in these cases we have to do not only with materials as such, but rather with the storage of energy in materials. The form value of many products of electrochemical industries is essentially due to their high energy content. A large amount of chemical energy is stored in electrochemical products; it is latent under ordinary conditions, but it may be gotten out wherever and whenever necessity arises, and this fact makes them useful and economically valuable.

Let us carry this consideration a little further by making use of the conception that the energy of a given system may be considered as the product of two factors —the capacity factor and the intensity factor, to use the terms of Ostwald. The total amount of energy remains the same, however the two factors may be changed, if only their product remains the same. But for the engineering applications it makes an enormous difference whether we make the capacity factor small and the intensity factor large or the former large and the latter small.

In case of a waterfall the amount of water passing over the fall in a certain time is the capacity factor, the height of the fall is the intensity factor. The engineering requirements for the development of a waterfall with little water and a high fall are very different from the case of a lot of water with a small fall, though the energy may be exactly the same in both cases.

In the case of electrical energy the current passing in a certain time, measured in coulombs, is the capacity factor, the pressure in volts is the intensity factor. For electric power transmission we make the intensity factor, the voltage, as large as possible, in order to decrease the transmission loss.

In the case of electrochemical products, the weight of the materials is the capacity foctor, the specific energy stored in them per unit of weight is the intensity factor. If we make the latter high, if we store a lot of energy in a little matter, it will again be favorable in reducing the cost of transportation.

Now the element of transportation brings us to the conception of the place value of electrochemical products. If their form value is due to their high energy content, their place value is due to the possibility of chemical power transmission by material transportation of electrochemical products. Those products of the electrochemical industries which are characterized by a high specific energy content are the principal medium of chemical power transmission.

There are two points of chemical power transmission to be specially emphasized. One is that it is not bound to a fixed route. It requires no line wires. It makes use of the ordinary transportation facilities for materials—railways, ships, etc. This is important, as it opens fields for chemical power transmission where electrical power transmission fails. For instance, there are still very large areas in this country, Canada and elsewhere which are so little populated that it would not pay to erect an electric transmission system to provide electric current for lighting. Here acetylene lighting is of supreme importance. And acetylene lighting is a case of chemical power transmission. At Niagara Falls the electric furnace produces calcium carbide from lime and carbon, and chemical energy is thus stored in the carbide which is transported with its energy to any place where acetylene is required for lighting.

If transportation creates place value, storage creates time value. The use of chemical energy after it has been transmitted is not bound to a certain time and that is the second important feature of chemical power transmission. With electrical energy which cannot be stored as such, it is necessary to use the transmitted energy at once or to provide special means for storing it. In this respect chemical power transmission differs essentially from electric power transmission and is superior to it. Chemical energy is in itself essentially stored latent energy, and is used, therefore, in connection with other systems of power transmission for storage purposes, as in the case of storage batteries for electric power systems. The time value of calcium carbide is due to the fact that we can store it and can produce the acetylene just at the moment when it is needed for lighting.

There is a long list of electrochemical products which may be considered from the viewpoint of chemical power transmission. In bleaching powder we transmit the possibility of producing a bleaching or a disinfecting liquid whenever and wherever it is needed. In the series of peroxides we transmit their avidity to give off an atom of oxygen when and where we want it, or the reaction caused by it.

As pretty and concrete an illustration of chemical power transmission as we may wish is found in Hans Goldschmidt's ingenious aluminothermic reaction. The heat of reaction of aluminium and oxygen in forming alumina is relatively very high per unit of weight of aluminium. This is just the reason why the economical reduction of aluminium from alumina did not succeed until electrolysis was resorted to. Now, the fundamental idea of the aluminothermic method is that we have in metallic aluminium a medium which gives us by combination with oxygen a large amount of energy where-ever or whenever needed. In thermit, the mixturue of aluminium and iron oxide, we transport essentially the capability of producing at any place and at any time highly superheated molten steel for welding rails, for making repairs, and so on.

Again, in the new and important Norwegian nitrate industry we have an example of what we may call international chemical power transmission, as the economical value of Norsk saltpeter depends on its easy transportation by ship to other countries. Thus we have at the same time creation of economic values in Norway by building up a new and important industry, and creation of economic values in other countries by using the Norsk saltpeter to further agriculture.

I have dwelt on the relation of electrochemistry to chemical power transmission at such length because so many electrochemical products can be considered from this viewpoint. But it would be wrong to think that the whole of electrochemistry can thus be viewed. There is quite a number of very important electrochemical products in which with no stretch of imagination I am able to detect the elements of chemical power transmission. But in all such cases the form value is high.

In the case of aluminium we have the aspect of chemical power transmission only in the aluminothermic reaction, which though big in itself, uses only a small amount of the total output of aluminium. In cooking utensils, in line-wire construction and other applications it is simply the mechanical and electrical properties of aluminium which count and which give it a high form value.

In electrolytic copper refining, the oldest and certainly one of the biggest electrochemical industries, the increase of form value is remarkable. It is a double one. First, the gold and silver are recovered; second, the copper itself is considerably increased in form value, due to its greater purity and resulting higher electric conductivity.

All those products of electrochemical industries which have nothing to do with chemical power transmission have a high form value, and must have it, because otherwise it would not pay to use an electrochemical process in view of the high cost of electrical power. Hence, the well-known axiom that in all such applications the use of electrochemical processes should be restricted as much as possible to the finishing touches, that is, to the refining of a comparatively advanced product.

In addressing the American Electrochemical Society I need hardly show at length how this creation of economic values by the electrochemical industries has affected and is affecting modern civilization in its various phases. What was waste before and what was considered a nuisance, becomes valuable. When the early Colorado gold seekers discovered tungsten ore in Boulder county they cursed it as it was not what they wanted. From their cursed "heavy black sand" electrochemistry has given to civilization ferro-tungsten and the tungsten lamp. From culm, the waste material of the anthracite coal mines Acheson has given to the world artificial graphite with its immense applications. Then there are the grand electric-furnace industries of artificial abrasives in use in so many walks of life. And so I could go on through the list of electrochemical products down to Cottrell's electrostatic process of recovering values from obnoxious smelter fumes. Only this, however, I should add, that electrolytic copper refining, itself made possible by the dynamo, has paid back its debt to electrical engineering, and by furnishing high-conductivity copper has made modern electric power transmission possible. And as we have seen, in chemical power transmission electrochemistry has brought into modern civilization an absolutely new element by which what is now waste power is being scattered all over the world to build up industries, to further agriculture with fertilizers, to light cities with acetylene, to aid public health with bleaching powder, and to affect civilization in general in its most heterogeneous aspects. That electrochemists as true creators are bringing about a revaluation of economic values there can be no doubt. But what has electrochemistry to do with æsthetics?

If beauty is perceived through our senses, the first question is: How has modern engineering affected our senses? And the answer is simply that modern engineering has given us artificial senses in addition to our natural senses. In the old days when the few pieces of apparatus in physical and chemical laboratories were home-made affairs, it was said that experimental physicists and chemists should be able to see with their ears and hear by touch, smell with their tongues and measure temperatures with their eyes. Now modern engineering has given us instruments and apparatus which really represent new senses and which are available to a much more general public. And what is more, our artificial senses can be repaired or replaced by new and better ones and they give us permanent records.

I am not stretching the meaning of the term senses in speaking of instruments as artificial senses. To the electrical engineer the readings of the voltmeter and wattmeter are as real and as true indications of the outside world as though he put his head out of the window to feel whence the wind blows. Pyrometers give as real, though much more exact indications of temperature, as the touch by hand of a hot body or the trained eye of the furnace man. The photographic camera is a new artificial eye that preserves the record of what it sees. Successive photographs put together in a moving-picture enable us to crowd into a period of five minutes what may have happened in a year. We can see crystals grow and plants grow. The electric oscillograph gives us a record that permits us to see at leisure transient phenomena that happen in portions of a second and study over them for hours. The telephone stretches the ability of the human ear so that it can hear in Denver what is said in New York. And if we hear our children of three or four years talk to us over the long-distance telephone in such a self-evident, matter-of-fact way as though they were sitting on our knees, we cannot escape the conclusion that a new generation is rising to which the perception of the outside world comes through new senses, and which consequently looks at the world with new eyes. What has electrochemistry to offer to this new generation in æsthetic ideals?

It seems to me that the fundamental contribution which electrochemistry has to make to æsthetics is to carry to its last consequence the principle that waste can never be beautiful. Of course, this principle is as old as art. Waste of words in a work of literature, waste of lines or colors in pictures, waste of space in architecture, have always been considered the opposite of beautiful. But the growing multiplicity of our sensual knowledge, due to the magnified and projected extension of our senses, forces us to see waste where our ancestors saw beauty and had a right to see beauty.

Permit me to concentrate my remarks on the one subject that is uppermost in this connection in the minds of American electrochemists—the question of the power development of Niagara Falls. I use it as a clear-cut example of what is meant by revaluation of æsthetic values by electrochemistry. The magnificent group of electrochemical industries of Niagara Falls, which are the pride of every American electrochemist and should be the pride of the whole American nation, suffers seriously from the power famine due to the cessation of power development by international agreement between the United States and Canada. This agreement is based on the alleged will of the people of both countries to have the falls preserved as a scenic spectacle on the principle of conservation of natural beauty. The battle cry is conservation of natural beauty for the people.

The counter-argument has been made that the natural-beauty conservationists want to conserve something that no longer exists. With this I agree, but I hesitate to agree with the expression usually given to this argument, namely, that if Niagara Falls could be preserved in its original magnificence, it would be worth while, but that Niagara as a majestic spectacle has never belonged to the present generation, that its beauty had been given up to noisy and offensive exploitation long before the first power station was erected.

This may be true, but it seems to me that this argument does not reach the root of the matter. The beauty of Niagara Falls, like all beauty, is subjective in the onlooker. The question is simply: What do we see when we stand at the brink of Niagara Falls?

Our ancestors who knew nothing of the principle of conservation of energy, of transformation of different forms of energy into each other, looked simply at the material side of the Falls and saw beauty and had a right to see beauty. And if we force ourselves into such a one-sided attitude of mind we can still see beauty.

But if we stand as modern men at the Falls with a free attitude of mind, we don't see simply water, we see power. We see the possibilities of using this power for electric power transmission for lighting, traction and industrial purposes on a wider area. We see the even greater possibility of storing this power in electrochemical products and utilizing them all over the land in all walks of life. If we look at the Falls with this attitude of mind which is the natural one for us, every cubic foot of water that goes thundering over the falls unutilized appeals to us as waste and nothing but waste.

Now waste can never be beautiful. If the artist's selection of the essential and nothing but the essential makes a work of art beautiful, anything that strikes our imagination as waste must prevent æsthetic enjoyment. If we could look at Niagara Falls with the eyes of our ancestors it would be different; but in full possession of our extended senses which an engineering age has given us, the Falls of Niagara—as much of them as is not utilized—must simply impress us as a waste of immense proportions.

And the very element of bigness which was an element of beauty to our ancestors, has necessarily become to us the reverse, emphasizing only more emphatically the criminal negligence of letting waste on such a tremendous scale go on. Undeveloped Niagara Falls remains spectacular even to the modern man, but it is no longer beautiful.

The perverse mind of Nero could enjoy the spectacle of Rome burning. Children and fools might naively delight in a conflagration that would consume for spectacular purposes a million tons of coal a week. We let the equivalent waste go on in waterpower and hear it called saving beauty for the people.

But there is little use in arguing in æsthetic matters. All we can really do is to make people see for themselves, use their own senses, all of them, their natural ones and their artificial ones. This is what engineering development tends to do every day; and we can rest assured that, as certainly as day follows night, a new generation is rising that will use its senses, all of them, and make its own æsthetics and enforce it.

And when that time has come and people look at the Falls of Niagara running dry their imagination will reveal to them immense beauty, health, wealth scattered by electrical and chemical means all over the country, while the grandeur of the whirlpool rapids, unchanged and undiminished will have a higher æsthetic value, a deeper meaning of beauty than it can possibly have for us. The world will then smile at the æsthetic scruples of so many well-meaning people of our own time and will wonder what all that talk of saving Nature's beauty was about.

---

**The Diesel Engine** is the title of an artistic, 112-page pamphlet, issued by the Busch-Sulzer Bros.—Diesel Engine Company, St. Louis, Mo. The catalog contains notes on the efficiency, economy, life, construction, operation and fuel of the Diesel engine, and gives illustrations of Diesel plants in 21 states.

**Silent Chain Drives.**—For the first time an engineering data book has been published by a manufacturing concern which will enable users of power to select the correct silent-chain drives for their work and determine exact costs from list prices shown in the book. Besides giving complete engineering information on silent-chain driving in simple and compact form, Data Book No. 125 describes many uses of silent chain for the efficient transmission of power and gives specific reasons and illustrations showing application in a large variety of uses. Link-belt silent chain is a series of links connected by joints which consist of segmental case-hardened bushings and case-hardened steel pins. The chain is as flexible as a leather belt—as positive as a gear. Its rated efficiency is 98.2 per cent on actual test. It will transmit any amount of power quietly. Over 200,000 installations were drawn upon for the information contained in this data book. The book is the only work of its kind. Copies can be obtained free of charge from the Link-Belt Company, Thirty-ninth Street and Stewart Avenue, Chicago, Ill.

## Celebration of School of Mines, Columbia University

Dr. Leo H. Baekeland will be the first lecturer in the Chandler Foundation on the afternoon of May 29 at Columbia University, during the celebration of the fiftieth anniversary of the founding of the School of Mines.

The celebration of the School of Mines begins on the evening of May 28 with a reception in the gymnasium, followed by a dance. On the morning of May 29 there will be a meeting in the gymnasium, at which eminent engineers will speak and honorary degrees will be given to graduates. An alumni luncheon will follow, and the Chandler lecture will be given in the afternoon, the celebration closing with the banquet at the Waldorf-Astoria in the evening.

## Personal

Mr. **Paul O. Abbe** has moved his New York office from Room 1203, Johnston Bldg., to Rooms 916-20, of the same building, where he will have larger quarters. Mr. Abbe has recently been made president of the Efficiency Engineering Company, 30 Broad Street, New York City.

Mr. **H. W. Hardinge**, president of the Hardinge Conical Mill Company, has returned to New York City from a two months' trip through the Western mining districts.

**Professor E. Heyn**, of Berlin, Germany, will deliver the annual May lecture before the Institute of Metals, London. Professor Heyn's subject will be "Internal Strains in Cold-Wrought Metals and Some Troubles Caused Thereby."

Mr. **Henry E. Jacoby** has recently concluded arrangements to act as the Eastern representative of the Vulcan Copper Works Company, of Cincinnati, Ohio, manufacturers of copper apparatus for industrial chemical purposes. Mr. Jacoby's offices are at 95 Liberty Street, New York City.

Mr. **Robert M. Keeney**, has resigned his position as electrometallurgist in the Bureau of Mines, to take effect April 30. He will go to Cornucopia, Ore., where he will have charge of the construction of a 100-ton cyanide plant, tramway and power house for the Baker Mines Co.

Mr. **Albert S. Knight**, of the International Acheson Graphite Co., is now in Europe on a business trip. During the next few months mail addressed to him in care of E. G. Acheson, Ltd., 5 Chancery Lane, London, will be promptly forwarded.

Mr. **William D. Mainwaring**, who for the past eleven years was connected with the Detroit plant of the Railway Steel Spring Co., as chemist and metallurgical engineer, has opened a consulting business at 866-868-870 Rockefeller Bldg., Cleveland, Ohio, as a production engineer. Mr. Mainwaring was formerly connected with the open-hearth department of the Pencoyd plant of the American Bridge Company, during the installation of the continuous process of the manufacture of steel. All the furnace records of his father, Isaac Mainwaring, who worked out the practical details as to furnaces and process at Chattanooga, Pencoyd and later in England, have recently come into his possession. He now has a continuous record of the progress of steel manufacture from 1891 to the present date.

Mr. **Wm. Acheson Smith**, general manager of the International Acheson Graphite Company, returned from a flying trip to Europe in time to attend the meeting of the American Electrochemical Society on the last day.

## Synopsis of Chemical and Metallurgical Literature

### Gold and Silver

**Nipissing Metallurgical Practice.**—The principal new features of the cyanide practice in the low-grade mill of the Nipissing Mining Co., Ltd., Cobalt, Canada, are a wet desulphurizing process to break up refractory silver minerals, and the substitution of aluminium dust for zinc as a precipitant. These and other details of Nipissing practice are given in a paper by **Mr. James Johnston,** published in the January "Bulletin" of the American Institute of Mining Engineers.

On the completion of the company's mill for high-grade ore, where a combination of amalgamation and cyaniding effects a total recovery of 99 per cent from 2500-oz. silver ore, investigations were begun on the best method of treating the low-grade material. Concentration and cyaniding were considered, the former producing a smelting product and the latter silver bullion 999 fine. The estimates of the two plans were as follows:

Comparison of Mills Treating 200 Tons per Day

| | |
|---|---|
| Commercial assay of ore........ | 30.99 oz. |
| Correction on pulp.............. | 1.10 " |
| Corrected assay ............ | 32.09 oz. |

| | | |
|---|---|---|
| Cyanide mill to yield 90% extraction. Approximate cost, $250,000. ........ | | |
| 90% x 32.09 oz. = 28.88 oz. at 52c., plus 3/10c. increase price in marketing .......... | | $15.16 |
| Working cost .......... | $3.00 | |
| Express on bullion, $3.50 per cwt. = 23c. per oz. on 28.88 oz. .......... | 0.07 | 3.07 |
| Profit per ton .......... | | $12.09 |
| Concentration mill to yield 80% extraction. Approximate cost, $160,000.......... | | |
| 80% x 32.09 oz. = 25.67 oz. at 52c.......... | | $13.35 |
| Working cost .......... | $1.25 | |
| Marketing concentrates, 10% .......... | 1.33 | |
| Difference between corrected and commercial assay on concentrates, 2% .......... | 0.27 | 2.85 |
| Profit per ton .......... | | $10.50 |
| Profit per ton, in favor of cyanide mill.......... | | $1.59 |

The actual results obtained in the cyanide mill finally constructed are as follows:

| | |
|---|---|
| Cost of construction............. | $254,839 |
| Extraction on a 26-oz. ore, per cent. | 92 to 93 |
| Working cost, per ton, less than... | $3.00 |
| Tonnage daily treated............ | 244 |

The following are representative costs for the concrete construction of battery foundation and walls for the building and ore bins.

| | |
|---|---|
| Battery block...... | 846 cu. yd. concrete |
| Building and walls. | 349 " " |
| Total .......... | 1195 " " using 945 bbl. cement |

| | | |
|---|---|---|
| Labor ................ | $2,669.48 | |
| Supplies ............... | 3,735.33 | |
| Lumber ................ | 246.57 | |
| Carpenter shop labor.... | 790.86 | |
| Machine shop labor..... | 87.78 | |
| Teaming ............... | 139.34 | |
| Fuel .................. | 12.85 | |
| Air for operating machinery .............. | 400.00 | |
| Total ................ | $8,082.21 | = $6.76 per cu. yd. |

Retaining walls and sundry small walls and foundations on the tank-floor level comprised 434 cu. yd., using 485 bbl. cement, and cost $13.09 per cubic yard.

The original estimated cost for the cyanide mill was $250,000. Following is the actual cost of construction, exclusive of the tram lines, washing plant, etc., which would have been common to either a cyanide or concentrating mill.

Cost of Construction of Low-Grade Mill.
To January 31, 1913

| | |
|---|---|
| Store and office buildings............... | $725.65 |
| Proportion office and supervision........ | 6,652.97 |
| Excavations .......................... | 29,728.30 |
| Foundations .......................... | 20,159.39 |
| Buildings over mill.................... | 24,618.99 |
| Battery equipment .................... | 24,241.42 |
| Proportion electrical equipment for above. | 5,267.38 |
| Tube mills and classifiers.............. | 23,223.80 |
| Proportion electrical equipment for above. | 12,091.02 |
| Slime treatment and storage............ | 31,519.84 |
| Proportion electrical equipment for above. | 4,477.26 |
| Cyanide filter plant................... | 14,154.92 |
| Proportion electrical equipment for above. | 3,040.71 |
| Piping, pumps, etc..................... | 12,886.19 |
| Precipitation ......................... | 9,989.23 |
| Proportion electrical equipment for above. | 239.42 |
| Heating plant ......................... | 12,333.70 |
| Water Service ......................... | 5,288.57 |
| Proportion electrical equipment for above. | 1,028.13 |
| | $241,666.89 |
| Additional cost for intermediate filtering and desulphurizing equipment not originally included ...................... | 13,172.63 |
| Total cost of mill.................. | $254,839.52 |

Briefly the mill practice is as follows: The ore is crushed to 3-in. in gyratory crushers and sent to the washing plant, where it is hand-picked and jigged. The high-grade material thus recovered is sent to the high-grade mill. The low-grade discard from the washing plant is crushed in stamp battery and tube mills in a caustic soda solution, producing a slime which is desulphurized in tube mill and vats containing aluminium. The slime is dewatered and transferred to vats for cyanide treatment, filtered and discharged to the dump. The cyanide solution is precipitated by aluminum dust, and the precipitate is melted and refined to silver bullion 999 fine.

The importance of extremely fine grinding was demonstrated in early experiments. It was considered that all the ore, silver included, should be ground to pass a 200-mesh screen, and then this product classified to take out the minus 200-mesh sand for regrinding, so that only about 15 to 20 per cent of sand, much finer than minus 200-mesh, would remain in the product delivered to the cyanide plant. As an example of the necessity of fine grinding, it is shown that when the pulp delivered to the cyanide plant contained 3 to 4 per cent plus 200-mesh and 30 to 35 per cent sand in minus 200-mesh, the residue after cyaniding will contain from 3.5 to 5 oz. silver per ton. When a grading test shows 0.5 to 1 per cent plus 200-mesh and from 15 to 20 per cent sand in the minus 200-mesh, the residue after cyaniding will contain less than 2 oz. silver per ton.

The wet desulphurizing process used to decompose the silver minerals was initiated by Mr. J. J. Denny. It rests on the fact that the refractory silver minerals are broken up when the slime pulp is brought in contact with aluminium in a caustic soda solution, leaving the silver in a spongy, metallic state readily amenable to cyaniding. This process is carried out by passing the slime through a revolving tube mill in which is a charge of 4000 lb. aluminium in cubes about 1½ or 2 in. After this agitation a further treatment is given in vats lined with aluminium plates, where the pulp is slowly agitated. This treatment reduces the time of treatment from 120 to 48 hours, and yields a better extraction by 1 to 4 oz. silver per ton. The slime thus treated is filtered before transfer to cyanide vats, where it is treated for 48 to 60 hours by air and mechanical agitation. This treated slime is filtered in a Butters plant, and the solution is precipitated with aluminium dust.

The practical benefits gained by aluminium precipitation are: No fouling of mill solution; more active solution; a regeneration of 0.608 lb. cyanide per ton of solution treated, equivalent to 1.67 lb. cyanide per ton of ore, or 408 lb. per day; recovery of silver precipitate averaging 27,000 oz. per ton, or about 93 per cent silver. The operating cost per ton of ore treated for July, August and September, 1913, calculated on the basis of 7320 tons per month, was $2.952.

**The Dome Mill, Porcupine, Ontario, Canada.**—Among the interesting papers presented at the annual meeting of the Canadian Mining Institute in 1913 was one on the cyanidation of gold ore at the Dome mine, by **Mr. D. L. H. Forbes.** Dome ore consists of quartz and schisted slate, heavily mineralized with pyrite. When ground it yields a small proportion of colloids, so that the pulp is ideal for settling and filtration under pressure. The gold generally occurs finely divided.

After crushing in gyratory and jaw crushers, the ore is fed to 1200-lb. stamps dropping 6½ in. at the rate of 102 drops per min. Ten-mesh rolled slotted wire screen is used, but tests have been made on other screens to determine the effect on stamp duty, as shown below.

*Effect of Screen Opening on Stamp Duty and Product*

| Mesh | Tons per stamp per day | Screen tests on battery discharge | | | |
|---|---|---|---|---|---|
| | | +60 mesh per cent | +100 mesh per cent | +200 mesh per cent | —200 mesh per cent |
| 16 | 6.8 | 41.6 | 8.8 | 10.4 | 38.8 |
| 14 | 7.9 | 62.0 | 6.4 | 6.8 | 24.8 |
| 12 | 9.0 | 64.0 | 7.0 | 6.0 | 22.8 |
| 10 | 9.6 | 59.0 | 15.0 | 7.0 | 19.0 |

When the mill was started there were primary amalgamating plates in front of the stamps, but with the coarse crushing finally adopted these were abandoned on account of the scouring action of the coarse sand. The relation of the screen used to recovery by amalgamation was as follows:

| Mesh of Screens used | Percentage recovery by amalgamation |
|---|---|
| 16 | 78 |
| 14 | 75 |
| 12 | 55 |
| 10 | 46 to 50 |

Following the stamps, the pulp is classified into sand and slime, the former being ground in tube mills and returned to the classifiers. The slime is passed over amalgamating plates, which recover from 46 to 50 per cent of the total gold, and thence through classifying cones to recover any coarse gold, amalgam, etc., which is returned to the tube mills. The most economical results are obtained when the slime is ground so that 75 per cent will pass a 200-mesh screen.

The slime leaving the classifiers contains 10 tons of water to 1 of solids. It is thickened in Dorr thickeners to a consistency of 44 per cent moisture. Cyanide is added to the thickened pulp in sufficient quantity to give a solution strength of 1 lb. per ton. The pulp is then agitated in a continuous Pachuca tank system, by means of compressed air at 20 lb. per sq. in. at the receiver. From the final treatment tank the pulp is run to a storage tank, where it is agitated and drawn off intermittently for filtration in Merrill presses. About 20 tons of slime at a dilution of 1.1 is drawn at each charge, filtered, washed with precipitated solution and discharged. A perceptible extraction of undissolved gold takes place during washing. The discharged pulp is again thickened for recovery of water.

The Merrill system of zinc-dust precipitation is used. The value of solution varies from $2.50 to $6 per ton. The precipitate has a value of about $40 per lb. The solution flowing from the press contains from a trace to 8 cents per ton in gold.

The method of preparing the zinc-dust emulsion is to grind the dust with solution in a small tube mill, and feed the discharge in definite amount at a uniform rate to the pregnant solution at the suction side of the pumps. The average consumption of zinc per ton of ore treated is about 0.37 lb.

Gold from retorted amalgam is melted into bars of 990 to 995 total fineness, of which about 100 is silver. The precipitate from the cyanide department is treated with acid, dried, fluxed, briquetted and smelted in a lead furnace. The resulting bullion is cupelled. The slag assays from $40 to $100 per ton, and is retreated later with cupel crusts, etc., whereupon the slag contains only about $3 per ton gold. Cupellation is carried to a point where the metal carries about 0.025 of lead. This metal easily breaks when cool, and is then charged into the tilting furnace, melted and cast into bars. The fineness of this bullion is 990.

Mill operations are controlled by assays of samples taken (1) at the battery pin, (2) at the discharge from batteries, (3) slime leaving amalgamation plates, (4) filter press residues, (5) sluicing water sent to waste with residues, (6) pregnant and barren solutions. Calculated heads, from gold recovered plus gold lost divided by tonnage, agree well with the average of battery samples, but do not check well with battery bin samples. Tonnage is calculated from samples of slime flowing from the tube mill circuit to the thickening tanks. As this pulp contains 10 parts water to 1 part of ore, errors are divided by 10 when referred to dry pulp.

The metallurgical extraction on half-ounce ore is over 95 per cent, divided approximately half and half between amalgamation and cyanidation.

**Cyanidation of Silver Sulphide Ore.**—The ore in the Ocampo district, Mexico, is practically all argentite, $Ag_2S$, with some associated gold. The ratio of silver to gold in the ore is about 60.1. The silver mineral occurs usually finely divided, but can sometimes be seen with the naked eye. Something of the history of the metallurgy of this ore, and the projected modern mill for its present treatment is told by **Mr. Robert Linton** in the February Bulletin of the A. I. M. E.

Six mills formerly were operated on the mines now owned by the Sierra Consolidated Mines Co., in the Ocampo district. Until about seven years ago the treatment consisted in plate amalgamation, followed by concentration with pan-amalgamation of the concentrates. Records show recoveries of from 62 to 79 per cent of the gold and from 46 to 64 per cent of the silver. The milling costs ranged from $3.25 to $5.01 per ton.

The first cyanide mill in Ocampo was installed in 1906. It comprised rock breakers, stamps, Wilfley tables, leaching vats for sand, Pachuca agitators for slime, clarifying filter press, zinc boxes and accessory equipment. Concentrates were ground in strong cyanide solution. Sand treatment required from 20 to 25 days, and slime treatment 8 to 10 days. The recovery was about 70 per cent for both metals, and cyanide consumption was more than 5 lb. per ton of ore. Milling cost averaged about $5 per ton.

Tests made under the present management indicated that sand leaching could be eliminated entirely, for better extraction could be made from slime. Where 80 per cent of the silver could be extracted from slime in 20 hours' agitation with strong solution, the extraction from sand at the end of 18 days rarely reached 75 per cent. Fine grinding is required to expose the silver to the dissolving action of cyanide; the more nearly a fineness of 200-mesh is approached the better is the extraction. The most favorable strength of cyanide solution is 0.32 per cent KCN, and at this strength extractions of 84 to 89 per cent of the silver and 93 to 95 per cent of the gold can be obtained in agitations of 34 hr. duration. Chemical consumption of cyanide is 1.4 lb. and of lime 12 lb. per ton of ore treated. Mechanical losses probably will bring these figures up to 2.5 lb. and 15 to 20 lb., respectively. Protective alkalinity should be maintained during agitation at 0.08. Lead acetate was found to be of no value in the treatment.

Tests on cyaniding concentrates showed the best results by grinding in 0.2 per cent KCN solution and agitating in 0.6 per cent solution, which was raised to 0.8 per cent toward the end of the treatment. Protective alkalinity maintained at 0.10. Lead acetate did not benefit extraction, but a small amount aided in keeping solutions clear. Concentration is not indicated in treating ordinary grades of this ore, though it might be valuable in handling rich ore.

A new mill, which had been designed on these tests, was under construction when work ceased on account of unsettled conditions in Mexico. The equipment will comprise rock breakers, 1500-lb. stamps, tube mills, Esperanza-type classifier, Dorr thickeners, Pachuca agitators, Oliver continuous filter, zinc boxes and accessory equipment.

The coarse breakers will reduce the ore to 2-in. size. This product will be screened over a 3/16-in. screen, and the undersize will by-pass the stamps, running to the classifiers. The latter will receive the battery pulp also and will deliver sand to tube mills arranged in closed circuit with the classifier. Agitators will be arranged in series for continuous agitation, giving a total time of 55 hr. in the tanks. The solution from the Oliver filter and from the overflow of the thickener preceding it will be clarified and precipitated. The mill has been designed in units, with a view to future enlargement.

### Lead and Zinc

**Selective Flotation by Horwood's Process.**—The Broken Hill correspondent of the Australian Mining Standard, Jan. 15, 1914, states that the successful establishment of the Horwood process of selective flotation at the works of the Zinc Corporation was one of the metallurgical achievements of 1913. The principle of this process is the roasting of mixed lead-zinc concentrates obtained by flotation, whereby the lead particles are slightly sulphatized while the zinc is unaffected. On floating the roasted product the zinc alone floats and the lead remains submerged.

A plant having a capacity of 500 tons weekly has been in operation for over six months, treating current and accumulated slime concentrates. The slimes are first dewatered and washed to remove soluble salts, then lightly roasted in an Edwards furnace, and finally treated again by flotation. Typical actual results from this plant are as follows:

| | Zinc, per cent | Lead, per cent | Silver, oz. per ton |
|---|---|---|---|
| Feed to roaster | 40.1 | 14.6 | 21.4 |
| Zinc concentrate | 48.7 | 5.2 | 11.6 |
| Lead residue | 10.2 | 44.2 | 54.6 |

The grade of the lead is, of course, dependent on the amount of gangue in the feed.

Tests made on Tasmanian ores show that 85 to 90 per cent of the zinc can be recovered as a concentrate assaying 57 to 58 per cent zinc, while the lead will remain with the iron content of the ore. From 75 to 80 per cent of the silver content of the ore and about 90 per cent of the gold will accompany the lead residue.

### Tin

**Assay of Tin Ores and Concentrates.**—In Bulletin No. 113, Institution of Mining and Metallurgy, will be found two papers bearing on methods of analysis of tin ores and concentrates. The first, by Mr. **H. W. Hutchin**, calls attention to the reaction occurring between tin ores and calcium carbonate, when a finely divided mixture is heated under proper conditions. The effect apparently is the formation of calcium stannate, which is readily soluble in hydrochloric acid. This solution can be reduced with nickel and titrated with iodine solution. The author presents many comparisons between Beringer's method and the lime modification, and shows results agreeing very closely. The operation may not be carried out successfully in the ordinary muffle furnace, but it is accomplished in the "tin furnace" described by Beringer in his Text Book of Assaying, or in an apparatus described by the author. Apparently the products of combustion play an important part, and must have access to the charge in the crucible. Alundum crucibles are preferred, but porcelain does well.

The apparatus suggested by the author is as follows: A piece of asbestos mill board, 6 in. in diameter and 1½ in. thick, is perforated in the center with a hole 2¼ in. in diameter. Three iron wire nails 5 in. long are inserted through the board from three equidistant points on the circumference and at a distance of about ⅜ in. from the base. The points of the nails may be covered with asbestos to prevent their oxidation, and the nails can be adjusted to support crucibles of different sizes. A Bunsen burner of large size, ⅝ in. diameter of tube, is used to supply the necessary heat. The crucible to be heated is suspended on the nail points in such a manner that the lower portion is below the board, and the upper portion affected only by radiation from the board. The cone of the flame should envelop the crucible. A large Techlu burner may be used. A charge consists of approximately equal parts of tin ore and calcium oxide, intimately mixed. The lime may be in excess. The reaction is complete in 20 min., with a Bunsen burner, and in 15 min. with a Techlu burner if an alundum crucible is used, or 20 min. with a porcelain crucible. The crucible is covered during the operation. After ignition the charge is brushed out of the crucible, dissolved in hydrochloric acid, reduced with nickel, and titrated with iodine solution.

The second paper on the same subject is by Messrs. **E. A. Wraight** and **P. Litherland Teed**, and consists in an investigation of the Pearce-Low method. In brief this method consists in fusing the finely powdered ore with several times its weight of sodium peroxide in an iron or nickel crucible, dissolving the fusion in hydrochloric acid, reducing with nickel and titrating with iodine solution. The authors investigate the effect of various elements which may be present in ores, and consider various other features of the method.

They conclude (1) that the ore should be ground to at least 100-mesh; (2) that nickel crucibles are superior to iron, as the latter may yield high results by contributing some ferrous chloride in the final titrating solution; (3) the amount of hydrochloric acid in the solution at the time of reduction should be 125 cc., and the bulk of solution should be about 400 cc.; (4) the temperature at titration should be not more than 70° F.; (5) the strength of the standard solution should not be more than 11 g. of iodine and 20 g. potassium iodide in one litre; (6) before titration the calcite that has been added to give a neutral atmosphere should all be dissolved; (7) titanium, tungsten and bismuth interfere seriously and should be removed; titanium by fusion with potassium bisulphate, solution of the fused mass with sulphuric acid and filtration, catching the tin on the filtrate; tungsten also may be removed in a similar manner, or it may be removed by filtration after reduction of the tin solution by nickel; bismuth may be removed at the same time as tungsten, by filtration of the solution after reduction with nickel; (8) nickel should always be used for reduction in preference to iron; (9) in rich ores, zinc, lead, iron, nickel, arsenic, chromium, copper, manganese, uranium, calcium, aluminium, sulphur, fluorine, boron and phosphorus do not interfere.

## Recent Chemical and Metallurgical Patents

### Iron and Steel

**Use of Raw Fuel in Blast Furnaces.**—Carbonized fuel such as coke and charcoal is generally employed in all kinds of blast furnaces. The use of raw or uncarbonized fuels has been attempted, but is accompanied with some difficulties, arising from the fact that the carbonization is not effected where most needed. The object of an invention by **Francois Prudhomme** of Vienne, France, is a device for shaft furnaces of all kinds making it possible to use raw fuels in such furnaces. In fact the furnace becomes an apparatus for carbonizing the raw fuel in the upper half and utilizing this fuel in the smelting operation in a lower zone.

Referring to Fig. 1, which is a vertical sectional elevation of a shaft furnace, the device is seen to consist in a number of superposed rings B provided with inclined tuyeres C entering the wall of the furnace and passing through it. These tuyeres and rings are connected through D with the air supply at E. The introduction of air through the tuyeres results in burning sufficient gases to carbonize the raw fuel, which subsequently reaches the level of the boshes at a relatively high temperature.

The advantages claimed by the inventor are the elimination of expense necessitated by separate carbonization; the use of the heat of the carbonized fuel, and the collection at the outlet of the shaft furnace of certain by-products. (1,092,168, April 7, 1914.)

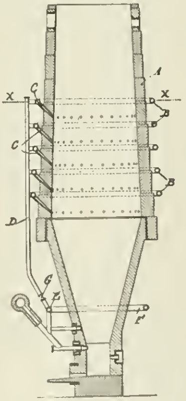


FIG. 1—BLAST FURNACE FOR UNCARBONIZED FUEL

**Air-Cooled Blast Furnace Stack.** — The cooling of thin-walled blast furnaces has usually been accomplished with water circulating through coiled pipes. Objections to this system of cooling are found in the consumption of water, the power required to force the water to the top of the stack, the loss of heat absorbed by the water, and the inability to rapidly control the cooling effect. Mr. **John J. Shannon** of Birmingham, Ala., proposes to utilize air as a cooling medium, particularly in that portion of the furnace above the bosh and crucible. Air is caused to pass through ducts formed by pipes cast in the metal stack-plates, either by a natural draft or forced draft. The cooling system may be so connected with the furnace stoves that the heat absorbed by the air when cooling the stack may be conserved. By this system the air flowing upwardly through the ducts exerts its maximum cooling where most needed, namely, at the bottom of the stack, and tends to radiate heat into the cooler top of the stack and thus maintain more uniform temperature conditions throughout the furnace walls. (1,090,574, March 17, 1914.)

**Welding Powder for Iron and Steel.**—According to a patent granted to Mr. **E. Ernst Eisengraber**, of Frankfort-on-the-Main, Germany, the following compositon forms a good welding powder:

| | |
|---|---|
| Red hematite................. | 70 per cent |
| Coal......................... | 22 " " |
| Flux......................... | 8 " " |

The flux used is sodium phosphate which favors the production of slag. Other fluxes such as fluorspar, cryolite and the like may be used. The welding powder is convenient for welding soft and hard steel and different kinds of steel and iron. (1,091,312, March 24, 1914.)

### Gold and Silver

**Aluminium-Precipitation of Cyanide Solution.**—The use of aluminium as a precipitant for gold and silver is not new. The metal is usually used in the form of dust, but as this method is open to some objections Mr. **Charles Butters** of Oakland, Cal., has proposed the use of aluminium in granulated or solid form. His process is carried out by passing the cyanide solution through a revolving tube mill containing a charge of aluminium in the form of small irregular bodies. The tumbling of the aluminium in the mill causes the abrasion of small particles and prevents the accumulation of gold and silver precipitated on the surface of the aluminium. The out-flowing solution which carries most of the gold and silver in suspension may be sent to a filter press for the recovery of the precious metals. (1,092,765, April 7, 1914.)

**Granulated Zinc Precipitation of Cyanide Solution.**—Zinc is used in two forms for the precipitation of gold and silver from cyanide solutions: dust and shavings. Both methods are open to certain objections which Mr. **Charles H. Urquhart** of Newark, N. J., proposes to overcome by using granulated zinc in a tube mill or other revolving drum through which cyanide solution is caused to flow. The granulated zinc is prepared by pouring molten zinc from a height of two or three feet into cold water. The product consists of small, irregular, unoxidized masses of brittle zinc which, when tumbled in the tube mill, break up into still smaller particles favorable for precipitating purposes. The inventor's apparatus is so arranged that the tube mill is at all times filled with cyanide solution so that no air is present. The outflowing solution carrying the precious metals in suspension is passed through a filter press or other suitable means of recovering the gold and silver. (1,090,661, March 17, 1914.)

### Zinc

**Isherwood Process for Refractory Zinc-Lead Ores.**—According to the patented process of Mr. **Percy C. C. Isherwood** of Bushey Heath, England, refractory zinc-lead ores are treated for the recovery of the zinc by roasting, leaching with sulphuric acid, and electrolyzing the zinc sulphate solution. The ore is first roasted under conditions which will yield both zinc sulphate and oxide, with no sulphide remaining. The leaching is carried out in two stages. First, in an open vat with a quantity of solvent less than that necessary for the solution of all the zinc in the ore; second, in a special form of extractor under pressure with an excess of the solvent. The extractor has been described in this journal, January, 1913, p. 54. The liquor obtained from the extractor is used as the leaching liquor for the first leach of a new quantity of ore. The ore remaining after the complete treatment may be treated for the recovery of any other metals contained. (1,089,412, March 10, 1914.)

**Magnetized Roasted Zinc and Iron Ores.**—A common method of separating iron and zinc minerals is to roast the ore to render iron magnetic and then subject the ore to magnetic treatment whereby the iron is removed. Owing to the fact that zinc minerals frequently carry combined iron, the magnetic gap between the iron ore and the iron-bearing zinc ore is not as wide as can be desired. In order to increase this gap and make it easier to separate iron and zinc minerals by magnetic separation Mr. **Geo. S. Brooks** of DePue, Ill., has patented a method of treating the ore after it has been roasted and prior to magnetic separation. In brief the process consists in subjecting the ore to the action of producer gas. The chief reaction may be expressed by the following:

$$3Fe_2O_3 + CO = 2Fe_3O_4 + CO_2.$$

The apparatus for carrying out this process is shown in Fig. 2. It consists of a long U-shaped chamber having a slope in the direction of its length. It is provided with a feed hopper C and discharge hopper *d*. Explosion doors are provided along the roof of the chamber. Producer gas is admitted through the flue D and the waste products escape at the opposite end through *m*. The hot, roasted ore passes through the chamber and is gradually elevated and dropped through the gas by slowly revolving cups *v* which are keyed on the central shaft. (1,090,516, March 17, 1914.)

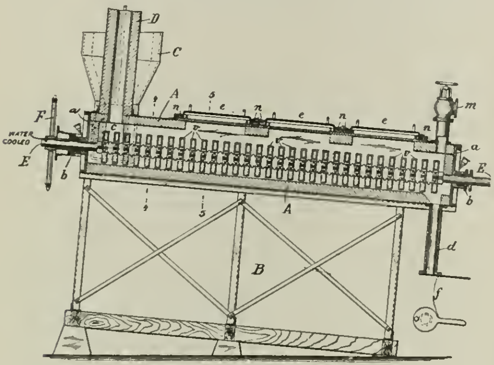


FIG. 2—APPARATUS FOR MAGNETIZING IRON-ZINC ORES

### Ore Cooler

In Fig. 3 is shown, partly in elevation and section, an ore cooler patented by Mr. Frederick Laist of Anaconda, Mont. The cooler consists of a drum which is set at an inclination to aid the passage of ore from feed to discharge end. Cooling is effected by a series of pipes placed along the inner surface of the drum, rceiving cooling water through pipe P. The drum is provided with water heads at both ends with which the pipes are connected. The water head at the feed end is not a part of the drum but is separated from it by space S. At this end the drum is closed by a plate through which the cooling pipes pass into the water head. The provision of this space permits expansion and contraction to which the drum is subjected. (1,090,549, March 17, 1914.)

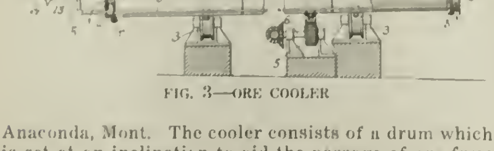


FIG. 3—ORE COOLER

### Aluminium

**Purifying Aluminium and its Alloys.**—The purification of molten aluminium from mechanically entrained impurities resulting from the melting of scrap metal may be accomplished by a flux of sodium chloride and sulphur, according to a patent recently granted to Mr. Grenville Mellen of East Orange, N. J. Molten sulphur and salt are thoroughly mixed and cast into rods which are then used to stir the molten aluminium which is to be purified. The sulphur vapors passing through the molten mass carry impurities to the surface where they form a flux with the salt. Additional fluxes such as sodium metaphosphate or zinc chloride can be added to the aluminium. The rod of salt and sulphur may contain 30 to 70 per cent salt. (1,092,935, April 14, 1914.)

An alloy of **aluminium**, zinc, copper, and silver has been patented by Mr. **William A. McAdams** of Bay Shore, N. Y. The metals are preferably combined in the proportion of 70 per cent aluminium, 26 per cent zinc, 3 per cent copper, and 1 per cent silver. The alloy will not tarnish and possesses great fluidity so that it will take the smallest impressions from a mold. (1,092,500, April 7, 1914.)

**Aluminium Solders.**—Mr. **Charles F. Grimm** of LeRoy, Minn., has patented a solder which can be applied to aluminium while the metal is cold. It consists of zinc 25 per cent, tin 50 per cent, lead 25 per cent. (1,093,403, April 14, 1914.)

A solder of **different formula** patented by Mr. **Auguste Cornande** and **Henri de Cruys** of Brussels, Belgium, consists of 52 per cent zinc, 17.5 per cent aluminium, 30 per cent tin and 0.5 per cent nickel. The nickel may be replaced by an equal amount of German silver. (1,092,340, April 7, 1914.)

### Alloys

**Acid-Resisting Alloy.**—An alloy which is said to resist not only the corrosive action of water and steam, but also that of sulphuric and nitric acids, is compounded as follows: Swedish iron 110 parts, nickel 90 parts, copper 1 part, aluminium 4 parts. Ordinary alloys of iron, nickel and copper have been objectionable because of the separation of the metals throughout the mass of the alloy. The inventor of the above formula, Mr. **Edward G. Gleason** of New York City, states that alloys within the proportions given above can be made without the use of any deoxidizing agent, and will be homogeneous and ductile. (1,093,557, April 14, 1914.)

**Making Titanium and Other Alloys.**—Various methods have been suggested for the reduction of refractory metals like titanium, and the production of their alloys with aluminium and copper. The objection to these methods, however, is they produce only alloys low in titanium, and when high titanium alloys are produced the metal is in the form of grains disseminated through the mass. According to the improved process of Mr. **Ernest Kraus** of Lynn, Mass., alloys high in titanium and other refractory metals can now be easily produced. According to one method, an intimate mixture of a compound of the refractory metal and a reducing metal, such as aluminium, is fed into an arc formed between a crucible and an electrode. When working thus with mixtures of titania and aluminium it is possible to get alloys containing as much as 94 per cent titanium. By a modified procedure the titania may first be fused in the arc, after which aluminium or copper or both may be added to the fusion. Reduction follows and a copper-aluminium-titanium alloy is produced. (1,089,773, March 10, 1914.)

### Metallurgical Furnaces

**Channel Furnace for Burning Ore Briquets.**—By the ordinary construction, channel furnaces are divided into upper and lower portions by the traveling hearth. The upper portion, in turn, is divided into a preheating chamber, a combustion chamber, and a cooling chamber. In order to utilize the heat of the burnt material, the combustion air is usually introduced at the rear of the furnace, in a direction opposite to the travel of the cars comprising the hearth, thereby preheating the air. The object of an invention of **Mr. Arthur Ramén of Helsingborg, Sweden**, is to provide an arrangement within the furnace whereby this preheated air from the cooling chamber will be introduced into the combustion chamber through a series of channels arranged in suitable relation with the gas inlets. In order to impart a suitable speed to this air and the gas with which it mixes, injector nozzles are arranged within the air channels, through which either preheated air or gas can be driven at a high speed.

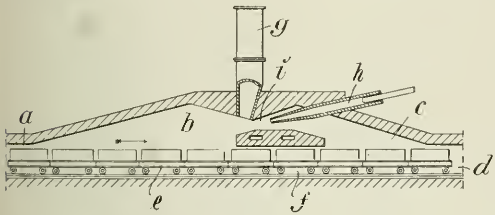


FIG. 4—CHANNEL FURNACE

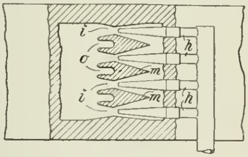


FIG. 5—ARRANGEMENT OF INJECTORS IN CHANNEL FURNACE

Fig. 4 shows a diagrammatic view of a channel furnace in which *a* is the preheating chamber, *b* the combustion chamber and *c* the cooling chamber. The gas inlet is shown at *g*. The tube *h* with the channel *i* forms an injector for introducing air (or gas) under pressure, thereby drawing in air from the cooling chamber *c*. Fig. 5 shows a plan of the arrangement, *m* representing partitions between the tubes *h* and the gas inlets *o*. The channels *i* may be used alternately for gas and air, thereby securing a "gallery" effect. A further advantage of the arrangement is a regulation of the quantities of gas and air over the entire width of the furnace, making it possible to use furnaces of three meters wide instead of 1.5 meters as before. (1,089,868, March 10, 1914.)

**The Fitz Gerald Laboratories, Inc.**, of Niagara Falls, N. Y., will carry on the business of Fitz Gerald and Bennie Laboratories, Mr. P. McN. Bennie having severed his connection with the latter.

### Mastic Lining for Acid Tanks

In connection with the operations of the Chile Exploration Company, in Chuquicamata, Chile, there has been developed a new method of lining concrete tanks which are subject to the action of sulphuric acid. Extended reference is made elsewhere in this issue to the nature of the metallurgical operations at Chuquicamata.

The company's copper ores in Chile are handled by the combined sulphuric acid and electrolytic method. After the ore is crushed it is put into large tanks or vats, and then leached with a 10 per cent sulphuric acid solution for forty-eight hours. The solution containing the copper is led through another process for extracting chlorine and then passes to the electrolytic tanks. There the copper is extracted and the remaining solution is then returned to the leaching vats ready for extracting the copper from a new batch of ore.

It can readily be seen that the large tanks required must be such as will withstand sulphuric acid, which, of course, concrete would not do unless provided with a protective lining. Experiments with tanks of various types were made, but in most instances proved failures. It was then suggested that an especially prepared acid-proof asphalt-mastic lining might be used to overcome the difficulties encountered. In coöperation with Mr. E. A. Cappelen Smith, consulting metallurgical engineer of the Chile Exploration Company, experimental tanks, among them one 15 ft. high, lined with Trinidad asphalt mastic, were installed at the research laboratory of the American Smelting & Refining Company, Maurer, N. J. With these tanks there was duplicated as nearly as possible the operation of extracting copper as it is carried out in Chuquicamata.

Under the direction of Mr. Smith various other materials were also experimented with at Maurer, but they all proved unsuitable, with the exception of the asphaltic mastic. It was on the strength of this material having shown no defects or deterioration after a year's test that the Chile Exploration Company has placed the contract for lining with asphaltic mastic some 150 concrete tanks or vats from 15 ft. to 16 ft. in depth and from 120 ft. to 150 ft. in exterior dimensions.

The lining of these tanks in Chile will require from 1250 tons to 2000 tons of asphaltic mastic, which is being prepared here and shipped to Chile. The first cargo of 500 tons was shipped in February, and as soon as it arrives, which will take about three months, as the ship has to go around the Horn, an experienced superintendent and nine mastic workers will be sent to Chile to do the lining of the tanks.

The experimental work at Maurer, the preparation of the asphalt mastic and its application to the concrete tanks was carried out by Mr. Henry Wiederhold, manager of the Vulcanite Paving Company.

---

### Removal of Arsenic from Sulphuric Acid

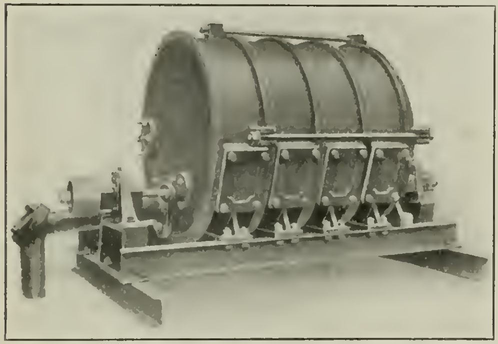
A new type of dearsenicator for the removal of arsenic from sulphuric acid is now on the market in the United States. It is different in principle from all the dearsenicators at present in use, the majority of which are the tower type. In all of these the sulphuric acid falls vertically over lead grids of various shapes which are so designed as to offer a large area to the action of the precipitant, which is hydrogen sulphide. The maintenance of these is expensive and repairs are frequent.

The Davis dearsenicator, which was developed by Davis Brothers, Manchester, England, and an outside view of which is given in the adjoining diagram, consists of an iron drum which is separated into several sections. This is lined completely with a special enamel which is quite resistant to sulphuric acid up to a temperature of 200 deg. C.

Inside each of these sections an enameled fan is placed so that about one-quarter of the blade dips beneath the level of the sulphuric acid passing through the drum container. These fans are attached to a common shaft and are revolved at between 40 and 60 r.p.m.

The object of the fan is twofold. It is designed to throw the sulphuric acid up as thin sheets and spray which enables the sulphuretted hydrogen to act very completely on the arsenic present in the acid. It also keeps the sulphuric acid, in each particular section, in constant agitation, preventing the settlement of the arsenic sulphide.

The vents in each section are so placed as to enable the sulphuric acid to run from one section to another until it reaches the outlet pipe. From there it is passed to filter tanks of special design. Schuler's filter tiles are used. The arsenic sulphide is completely filtered out here. The excess of sulphuretted hydrogen is either absorbed by caustic soda solution or milk of lime.



DEARSENICATOR

These dearsenicators are made in all sizes from 20 tons to 500 tons capacity weekly. They are remarkably efficient, giving a production containing from 1.5 parts arsenic per million to 1 part arsenic per million parts sulphuric acid. They will do this starting with an acid containing as high as 0.5 per cent arsenic and the average cost of treating per ton is 30 cents. There are a number of these at present in use in Great Britain, one of which has been in use for over two years without any deterioration or repairs. This type of dearsenicator never chokes up and never requires cleaning.

It also occupies less space than any other type at present in use.

Dearsenicators for sulphuric acid are of a special interest on account of the even more stringent requirements of the recent pure food and drug act.

Acid made from pyrites and treated with hydrogen sulphide in this manner is more pure than acid ordinarily made of sulphur as all the lead, copper, antimony and bismuth are also, of course, completely removed. For this reason the new dearsenicator should be particularly welcome to all who have experienced troubles from the pure food and drug act.

The dearsenicator having a capacity of 200 tons O. V. per week occupies a floor space of about 6 ft. by 3 ft. 6 in. and weighs approximately 3600 lb. The Davis "Trepex dearsenicator" is being introduced in this country by Industrial Research, Inc., 50 East Forty-first Street, New York City.

## Improvement in Forging Practice

Notwithstanding the fact that the need for increased efficiency has long been apparent in forge-shop practice, practically all of the progress has been on machine design, and the heating side has been either too lightly considered or entirely overlooked, although in many cases the cost of heating is greater than that of operating the machines. The result has been that the output of the modern machines has been restricted by the inability of the furnace and the man to keep up with them, and worth while savings in cost of manufacture lost. This is particularly true in connection with the heating of small and medium-size work, such as bolt and nut stock, wrench and hammer parts, springs, shears, snips, cutlery, and a great variety of general drop forging and light hammer work.

Forge furnace design and principle of operation have been quite generally befogged by discussions of fuel prices, burner efficiencies, and other details merely incidental to the operation; and too little attention has been paid to the basic principles of proper combustion, chamber provision, protection for the stock, even heating, etc., as well as the more practical question dealing with the protection of the operator.

Efforts have been made to reduce fuel consumption, but in practically all cases the progress in this direction has been at the expense of the quality and quantity of the stock handled, due to the fact that the efforts made to remedy the difficulty have been along the lines of dealing with the effect instead of the cause.

To relieve these conditions the W. S. Rockwell Company, furnace engineers, 50 Church Street, New York, have patented and introduced a new type of forge furnace which not only makes it possible for the operator to work to better advantage and keep up with his machines but offers other inducements in the way of decreased operating costs.

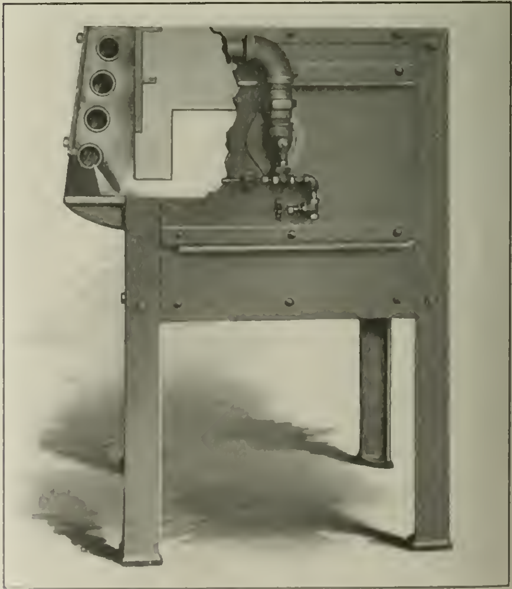


FIG. 1—FORGE FURNACE

The furnace has been successfully tried out under actual working conditions in the manufacture of a variety of products, and its worth has been demonstrated in competitive operating tests which have led to its adoption in a number of large installations.

The design of the furnace, as shown in the illustrations, involves, among other features, a special economizer shield over the working opening, which recovers a large percentage of the heat ordinarily wasted, and also a novel arrangement of blast which acts as a barrier between the operator and the heat and enables him to work closer to the furnace and handle his material faster and with less effort and discomfort.

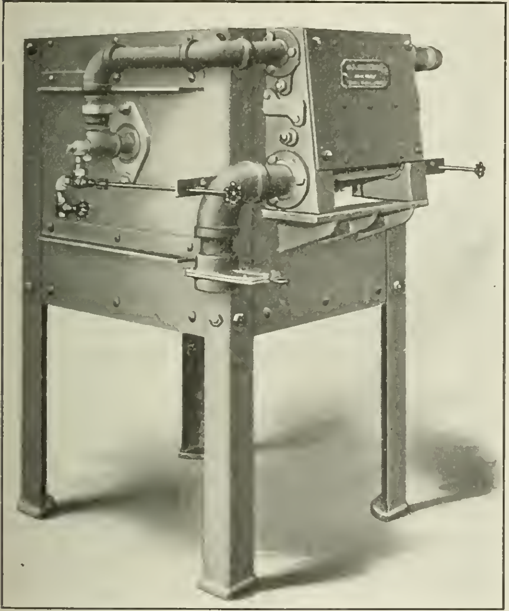


FIG. 2—FORGE FURNACE

In the operation of the furnace the spent gases discharged from the working opening are deflected by the blast away from the operation and against the tubes and headers of the economizer, through which the air for combustion is circulated, with the result that the air, taking up heat in its passage, is delivered hot into the furnace with the fuel.

The utilization of the waste heat not only means economy in fuel, but in the volume of air introduced into the furnace, which not only tends to decrease the power required to deliver the air, but the amount of oxidation as well.

The provision for combustion is such that the heat is applied uniformly on all sides, and the ill effects of varying temperature or composition of the usual "flame" are eliminated. There is a thorough mixture of the gases, which, with the help of the heated air, makes it possible to maintain clean, soft, soaking heats, which in practice have been found to materially reduce the amount of scale on the stock and in some instances to the extent of doubling the life of the dies.

In front of the working opening is a blast forming a curtain of air under pressure, through which the operator works and the full mechanical effect of the pressure is available all the time, or whether the stock be partly without or entirely within the furnace chamber. This blast not only acts to deflect the waste gases into the economizer, but to protect the operator as well, and it has been found in tests running over a period of several months that the more comfortable working conditions enable him to handle his material to much better advantage and in some instances from 60 per cent to 75 per cent more than had previously been heated in the same hearth area.

The advantages of the construction include reduction in consumption of fuel and air, protection for the operator, greater output for the same heating area, reduction in amount of scale, increased die life, as well as cleaner shops and more healthful working conditions for the men, with less heat, smoke, noise and dirt.

## Silico-Manganese

The following notes on silico-manganese, made by the Vargöns Company at Trollhättan, Sweden, should be of interest, as this alloy has found considerable use in European steel works as a substitute for ferrosilicon and ferromanganese.

The silico-manganese has the following analysis:

| | |
|---|---|
| Silicon and manganese together...... | 90.096 per cent |
| Phosphorus .................. | 0.030 to 0.070 per cent |
| Sulphur ..................... | 0.010 to 0.015 per cent |
| Carbon at 17 per cent silicon abt........... | 2 per cent |
| Carbon at 25 per cent silicon abt.... | 0.3 to 0.5 per cent |
| Carbon at 30 per cent silicon abt.... | 0.1 to 0.2 per cent |

The proportions of silicon and manganese can be varied so that any alloy containing between 17 to 50 per cent silicon and the manganese between 73 or 79—40 or 46 per cent can be had.

The addition of silico-manganese to the molten steel is done in the same way as for ferromanganese and ferrosilicon.

The advantages claimed for the use of silico-manganese are as follows:

Ferrosilicon and ferromanganese (especially ferrosilicon) add, as well known, to the molten steel a considerable amount of cold iron, which is cooling down the steel at a critical moment; the silico-manganese, on the contrary, is composed almost entirely of manganese and silicon, and therefore the chilling effect is very much reduced.

The manganese is better protected for oxidation on account of the perfect mixture of silicon and manganese in this alloy; therefore the amount of manganese to be added is less than if using ferromanganese. In fact, experience shows a saving of about 10 per cent.

It also follows that it is easier to attain the exact amount of manganese in the steel.

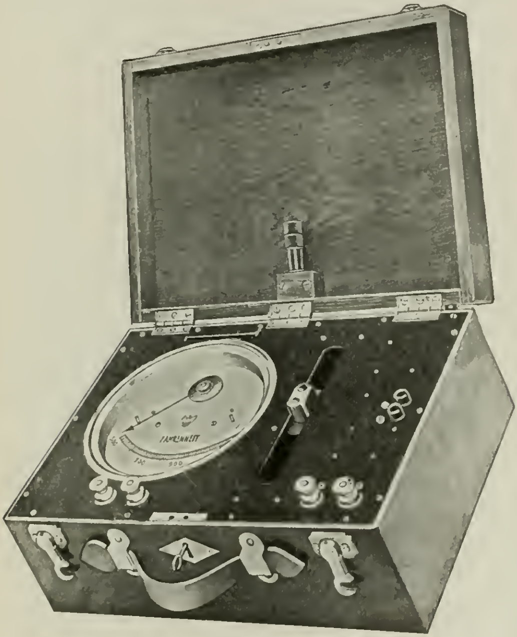
The percentage of carbon in the silico-manganese is low in comparison with ferromanganese, which of course is of great benefit, taking into consideration the recarburizing through the alloy. This is especially important in producing soft steel, and experience has shown that time is saved in making a heat, which means lower costs.

The silico-manganese is made from very pure Swedish manganese ore, very low, as shown by analysis, in phosphorus and sulphur. This has proved to be of great value in producing high-quality steel.

The American Bridge Co., Chicago office, confirms the report that it has the contract for 6000 tons of steel from the International Smelter & Refining Co. to be used in the erection of a new smelter at Miami, Ariz., to cost about $2,000,000. D. A. Welch, Butte, Mont., of the Anaconda Copper Company, is purchasing agent.

## Combination Portable Testing Set Using Resistance Thermometers and Pyrometers

For those requiring a temperature measuring instrument for low, intermediate and high temperatures, a recent development by the Hanovia Chemical & Manufacturing Company, of which Mr. Charles Engelhard, 30 Church Street, New York City, is the president, will be of special value, combining, as it does, instruments for widely varying temperatures in a compact, convenient form for portable use. The instruments employed are Heraeus quartz glass resistance thermometers and the well-known Heraeus Le Chatelier pyrometers.



COMBINATION TESTING SET

The resistance thermometers consist of a resistance spiral of chemically pure platinum, which is imbedded in quartz glass, thus insuring no contamination of the resistance spiral by injurious gases and no change in resistance by evaporation. These thermometers are mounted in any form suited to best meet the requirements of the purpose for which they are to be used. Their temperature range is from —330 deg. F. to + 1300 deg. F. and an accuracy of $\frac{1}{2}$ of 1 per cent of their scale range is guaranteed.

The Heraeus Le Chatelier pyrometers are too well known to require detailed description here. For use with the combination portable sets, they are mounted in a convenient portable form, suitable for the measurement of temperatures up to 3000 deg. F.

Only one indicating instrument is used which is graduated with two or more scales, depending upon requirements. The thermometer scales may be between any desired limits within the range of the thermometers themselves, and the pyrometer scale is graduated from 32 deg. F. to 3000 deg. F. For example, the indicating instrument could have two thermometer scales, one graduated from 30 deg. F. to 300 deg. F. and the second from 500 deg. F. to 1000 deg. F. and the pyrometer scale from 32 deg. F. to 3000 deg. F.

The sets can be supplied for practically any number of thermometers and pyrometers, and the change from one scale to another and from one thermometer or pyrometer to another is made by the pressing of a button.

The indicating instrument, and all switch and regulating arrangements, are neatly mounted in an oak carrying case, which can be carried inside of an ordinary suit case. The thermometers and pyrometers are also provided with a suitable carrying case.

The special field for these instruments will, of course, be for portable testing work—as for example, in power plant testing, for consulting engineers, demonstrators, etc.

As a practical illustration—in boiler testing the pyrometers could be used in the firebox, flues and stack, and the resistance thermometers in feed water, economizers, condensors and superheaters. One man can take all these temperatures practically simultaneously, and at a point anywhere convenient to himself, as the distance between the thermometers, pyrometers and indicating instrument does not in any way affect the accuracy of the indicated temperatures.

These instruments will fill a long-felt want for a suitable means of accurate testing, where widely varying temperatures must be measured and where requirements demand a compact and easily transportable instrument.

---

## Uses of Asbestos and Its Products in Chemical and Metallurgical Industries

Asbestos holds an unique position among minerals on account of its peculiar physical properties. Since its original discovery it has found a wide variety of industrial applications and has been transformed from a mineral curiosity into an industrial necessity. When treated mechanically it yields soft, white, delicate and exceedingly strong fibers, which can be spun, woven and otherwise manufactured into many useful articles. In addition to its fireproof qualities it is acid-proof and practically indestructible. It also forms a valuable insulator for electrical purposes. Just how extensively asbestos products are used may be gathered from the fact that the H. W. Johns-Manville Co., New York, manufacturers of asbestos products, occupies its own skyscraper business building in New York City (quite close to the Chemists' Club), and maintains forty branch offices in different parts of the United States.

As a heat insulator asbestos finds application in a way that directly affects the cost-sheet. The loss from radiation and condensation due to uncovered or improperly covered pipes, boilers, or furnaces directly affects the coal pile. High-class insulation is absolutely imperative owing to the present high cost of fuel and the growing demand among manufacturers to reduce the unit cost of production to a minimum. Every dollar wasted in fuel consumption detracts from the earning capacity and the profits of the plant. Asbestos insulating materials are the outcome of careful, practical experiments in this field, and have demonstrated through many years of hard service their peculiar adaptability to the purposes for which they are recommended, and the maximum earning power in coal saving. The best insulation is none too good to meet the increasing severity of modern requirements.

Asbestos pipe coverings are made in a variety of forms, such as a mixture of asbestos fiber and magnesia; a light cellular construction of asbestos paper, and a combination of molded asbestos with a covering of wool felt. Other forms of insulation are made for brine, ammonia, ice-water and cold-water pipes.

It is quite as important to cover boilers, domes, cylinders and large surfaces as it is to insulate pipes. For this purpose asbestos sheets and blocks are used, under conditions where the expansion and contraction of large surfaces would injure cement coatings. Insulating cements of asbestos and magnesia, mixed with water to the consistency of mortar, are applied as coatings over sheets or blocks.

Among the most annoying items of expense in boiler maintenance are the up-keep of fire-brick walls and arches and the cost of delay in cooling down a boiler for repairs. This is largely due to the inefficiency of fire-clay—which heretofore has been the only available bond for setting up fire-brick.

Fire-clay readily fuses and runs, opening up the joints between bricks. In addition to this refractory bricks are porous. Hot gases of combustion enter into the pores of the bricks and into the joints when the fire-clay has fused out, weakening the bricks and eventually causing the whole wall to break down. Cements of asbestos and other refractory materials have been found useful, preventing these conditions.

A plastic asbestos retort cement has found application in gas and chemical works for repairing broken clay and iron retorts and pipes, and cementing fittings, connecting pipes and flange-joints, also for cementing joints in stone, wood and metal. It can be easily applied with a trowel. It hardens rapidly, vitrifies without shrinking when subjected to intense heat and is fire and acid-proof. It is not injured by acids, petroleum oils, etc., and effectually prevents the escape of vapors.

Acid-proof cements are now made which meet other needs in the chemical industry. To the users of acids, either in concentrated or diluted form, the problem is ever present of how to convey them to different points at least possible cost, without the possibility of leakage, resulting in damage to stock and machinery as well as building, also loss of money by waste of acids.

Acids, even in diluted form, will gradually disintegrate and destroy iron and wood, and will in time make a building unsafe.

The storage of acids in bulk and the use of same in tanks is a still further source of trouble because of danger of leakage and subsequent damage. These problems can be solved by the use of a particular form of acid-proof cement.

Of interest to the foundry and machine shop are certain metallic compounds made by the Johns-Manville Co. These are used for smoothing over and filling up blow-holes and sand-holes in iron and steel castings, making pipe joints and stopping leaks in steam, water, gas, oil, ammonia and brine pipe-lines without removing them from position.

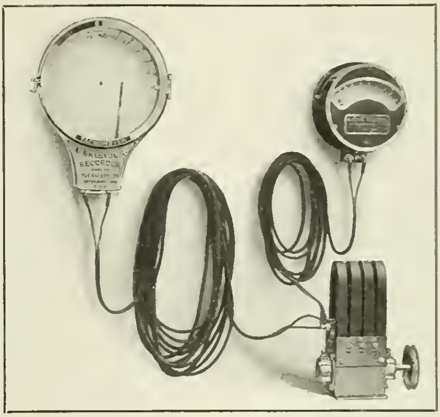
Asbestos roofing material is now widely used in the protection of buildings used for chemical, metallurgical and other industrial purposes. In addition to the qualities possessed by other roofing materials, asbestos affords fire protection and acts as a heat insulator. A roofing material composed of asbestos felt impregnated with refined asphalt gives service that makes its use inexpensive when cost of maintenance is taken into consideration.

A great deal of detailed information regarding these and other asbestos products is contained in a long series of catalogs and bulletins issued by the H. W. Johns-Manville Co., Forty-first Street and Madison Avenue, New York City. Any of these publications will be sent on request to applicants who are especially interested in the subject.

## New Electric Tachometer

The field of usefulness for recording tachometers includes use in connection with all engines, machinery or revolving shafts wherever information is desired about the rate of speed at which shafting or any other devices are revolving. Some of the most important applications are in connection with engines, turbines, generators, paper machines, blast furnace blowing engines, motors and pumps. Recording tachometers are usually required for continuous service under ordinary shop or mill conditions and for this reason must be made rugged and durable to be thoroughly successful.

A new Bristol electric tachometer of the alternating-current type which is particularly well suited to rough operating conditions in mills, power plants or shops is being put on the market by The Bristol Company, Waterbury, Conn. Although this is an electric tachometer, no sliding contacts or brushes are used in it and no delicate millivoltmeter movements are required.


ELECTRIC TACHOMETER

Two of the most important features of this electric tachometer which make it particularly strong and durable are the induction magneto and the voltmeter movement. The magneto as shown in the accompanying illustration is of the induction type without any sliding contacts or brushes. The indicating and recording instruments are voltmeters. The indicating instrument is equipped with a Weston pivot jewel-bearing voltmeter movement. The recording instrument is equipped with an improved Bristol voltmeter movement so designed that there is plenty of power available for actuating the recording arm even though the recording pen is in continuous contact with the surface of the chart. In this recorder the movement is mounted on frictionless knife-edge bearings. This movement is equipped with a new patented supporting device for the moving elements designed to eliminate temperature error. This recorder can be furnished for use with either 12-in., 8-in. or 6-in. charts.

The accompanying illustration shows a combination indicating and recording unit which provides an indicating instrument for the operator at his post of duty and a recording instrument for the superintendent or foreman in his office. By the use of suitable lengths of leads, either instrument can be placed at almost any point desired, and more than two instruments can be connected to meet special conditions.

## A Novel Branch of Research

"Research work on research apparatus" sounds rather extreme, yet is actually done in Pittsburgh in a very practical way. The demand for a research department came to the Scientific Materials Company in connection with their regular laboratory supply business.

Special apparatus for research is not, however, the only line of work followed by this department, as it also carries on the work which deals with the designing and testing of all new apparatus or improvements in existing types.

This new department really marks an epoch in the development of this company and illustrates how the field of laboratory apparatus has grown. Five years ago the business of supplying laboratories was in itself considered a specialty, yet today it has become necessary to specialize in this same field. In the beginning the demand for different apparatus was comparatively small in each instance, and the natural tendency was to adopt the nearest thing available, at least in part. But the rapid advance in science has caused a demand for a corresponding advancement in scientific apparatus, and the work of meeting this demand now requires a separate organization of its own.

This specialization by means of a separate department for designing and improving apparatus bids fair to add its share to the great progress now being made in chemistry, metallurgy and biology. This is especially so when we consider that many scientific discoveries follow in the path of improvements in the apparatus with which the scientist must work.

In organizing this special work the idea of the late Robert Kennedy Duncan of isolating the men with their problems has been carried out, and this department is relieved of all responsibility of routine, manufacturing, etc. The responsibility of the research department ends after a new piece of apparatus has been designed, tested out and turned over to the sales end of the organization. The many laboratories about Pittsburgh, including the United States Bureau of Mines, the United States Bureau of Standards, the Mellon Institute of Industrial Research and others, were constantly requiring special apparatus in connection with their research work. The men employed in the laboratories, however, had their own problems to solve and preferred to be relieved of the work in connection with the designing and testing of the necessary special apparatus.

The Scientific Materials Company was called upon for this work, and by adding it to the original work which they had been doing in designing and improving apparatus for the regular market, they found that a separate department was necesary to carry on the work successfully.

The department is in charge of a graduate electrical engineer who gives it his whole time and acts as director. He is assisted by a graduate chemical engineer, a sanitary engineer, a mechanical engineer, a pyrometric engineer, a mining engineer, an expert glass blower, and two precision mechanics. At the present time five of these men give their entire time to the research work, and as all the other men are in the regular employ of the company they work from time to time in connection with the others just according to the problems on hand, and also act in a consulting capacity.

When a particularly difficult problem arises, a conference of the staff is called and the problem is presented by the director, and after a general discussion the different ideas and suggestions are obtained. This is very valuable as the staff, on account of their different lines of training, view the problems from as many different angles.

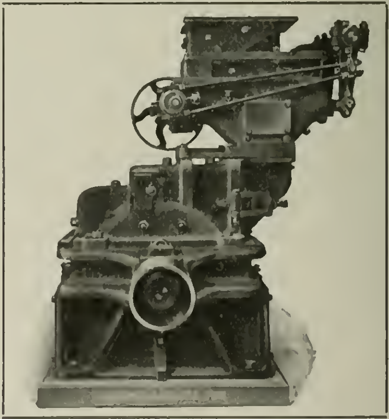
The reference library used in connection with this work is also unique in that it embodies the catalogue file of the import department of the same company, which contains the trade literature of practically every scientific apparatus manufacturer throughout Europe.

This work has been going on for some time and the first bulletin, "Errors in Bacteriological Incubation," has been issued. This bulletin gives in condensed form an outline of the difficulties encountered, especially in incubators, and tells in detail how they are now overcome in a perfected form of apparatus.

## Hammer-Bar Pulverizer

The Sturtevant Mill Company of Boston, Mass., have placed on the market a machine which is claimed to be an improvement on other impact pulverizers both mechanically and in principle of operation. The Sturtevant hammer-bar pulverizer crushes soft and moderately hard materials (up to and including all limestones in hardness). It represents the greatest efficiency in a mill of this class.

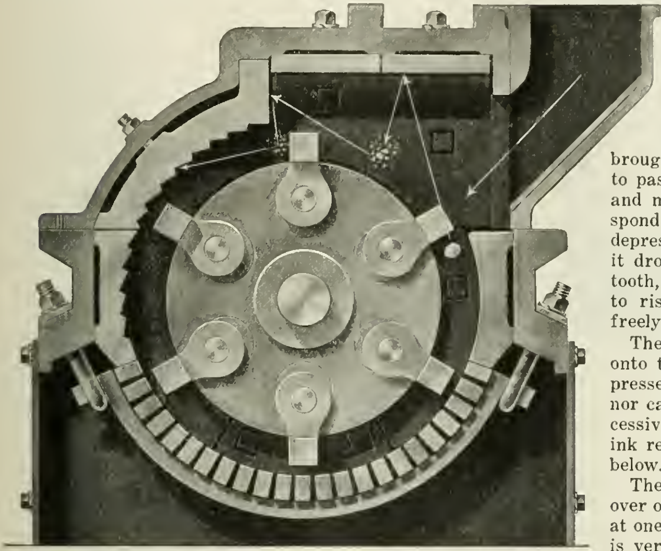
The material fed may be as large as 4″ to 5″ in size, with soft rock, varying to 1½″ to 3″ for harder substances.



HAMMER-BAR PULVERIZER

The rock is fed from an automatic feeder which drops it on the heavy hammer-bars of manganese steel which move *upward* to meet it at high velocity (just as the bat meets the flying base-ball). The impact is tremendous and the rock is smashed up against an armor breaking plate, from which it rebounds against another hammer bar swung up against it with the same smashing effect. Thus are dealt, against the rebounding rocks, a succession of terrific blows, and plate collisions (that recur 7200 times a minute), resulting in an immense output of powdered stone.

It should be noted that the smashing action already described represents the *upward* stroke of a bar hammer against rock rushing to meet it. The result attained represents the highest possible efficiency. But when the hammer bars begin their downward path, efficiency is so diminished (the bat chasing the ball strikes a feeble blow) that another plan must be adopted—and the descending hammer bar is now brought close to a corrugated breaker plate where the greatly reduced broken stone is further pulverized between the high-speed hammer bar and the corrugated plate in close relation thereto. The hammers now pass close to the bar grate, made of the hardest steel, 1¾" deep. The ground rock dashed through the openings of the grate is sufficiently pulverized, and is now violently ejected from the case. This relieves the hammers which otherwise would drag through material already sufficiently reduced. Thus there is no finished rock left to repeat the circuit and waste power.



INTERIOR VIEW OF HAMMER-BAR PULVERIZER

It is clearly seen that as soon as the hammers begin to rush upward again against the incoming rock, they resume their work of rock destruction.

This mill is built extra heavy, and runs with practically no vibration, as it is perfectly balanced, and the hammer bars, held strongly out by centrifugal force, revolve with the sustained regularity of a heavy balance wheel. The bearings are of ample proportion, self-oiling, and dust proof. The hammer bars are of manganese steel, and the screens of the hardest and strongest material obtainable. "Open-door" construction affords immediate access to the interior of the case for inspection, and replacement of hammers, or grates, or screens.

## New Recording Pyrometer

A new recording pyrometer, recently perfected by the Thwing Instrument Company of Philadelphia solves the problem of "how to carry water in a bottomless pail," the chief feature of the recorder, from the standpoint of originality, being the new capillary ink-pad.

Fig. 1 illustrates the principle upon which this new ink-pad operates. A horizontal plane of brass is mounted above the drum which carries the chart. In this plane of brass, or ink-pad, is a circular well (C), which is filled with ink, and a V-shaped groove (D), corresponding to the arc through which the needle (E) will travel, as actuated by the thermoelectric force of the thermocouple. This V-shaped groove is open at the bottom, so that the needle (E) may be depressed through the groove upon the chart below.

As the inkwell (C) is filled the ink spreads by capillarity to the extreme end of the groove, so that a film of ink separates the needle, when elevated, and the chart. The depressor arm (G) is attached to a depressor lever mounted on the face of the clock, in the lower section of the recorder case, the clock also being employed to drive the drum carrying the chart. Underneath the depressor lever, on the clock face is a contact wheel having regularly spaced teeth with a gradual rise and abrupt drop.

As the depressor lever travels on the rise of the tooth the depressor arm (G) is raised, tilting the actuating lever (A) so that the depressor bar (B) is brought down upon the needle (E), causing it to pass through the film of ink in groove (D) and make a dot of ink upon the chart, corresponding to the temperature and time. As the depressor bar reaches the summit of the tooth it drops abruptly into the bottom of the next tooth, drawing (A) downward and causing (B) to rise, permitting the needle (E) to swing freely above the groove (D).

The ink will not follow the needle (D) down onto the chart, even though the needle be depressed long enough to make a continuous line, nor can it be jolted through the groove by excessive vibration, but remains a clear film of ink ready for countless records upon the chart below.

The advantage which such a recorder has over one which must return to an inkpad, placed at one side of the chart, for a new supply of ink is very apparent. The frequency of record is much higher with this capillary type of inkpad, as the needle is always in circuit with the thermocouple and is always at the correct position for temperature record, hence it is merely a matter of the frequency with which it is desirable to depress the needle upon the chart.

This type of inkpad has been used for about a year by such gas companies as the Consolidated Gas Co. of N. Y., United Gas Improvement Co. of Phila., for recording temperatures of water gas machines. On the carburetors of such machines it is necessary to secure frequent records of temperature, as the temperature rises and falls very rapidly as the oil is sprayed into the carburetor, the cooling of the gas

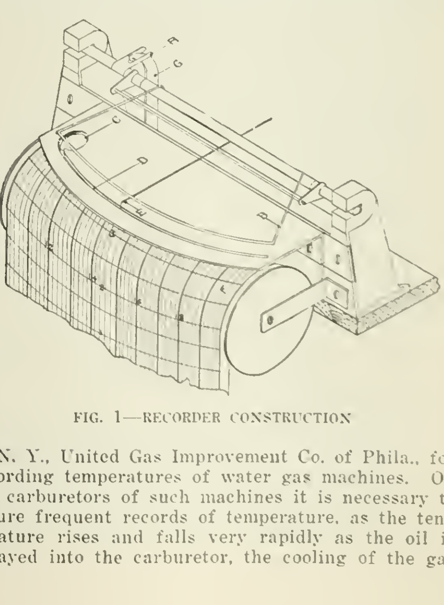


FIG. 1—RECORDER CONSTRUCTION

as the oil is turned on and its return to the proper temperature covering several hundred degrees in a space of a few minutes. With three records per minute, as made by the capillary inkpad, it was found that practically a continuous line was obtained, each operation being rendered distinct by its minimum and maximum temperature.

Another field in which this type of inkpad is invaluable is in constructing "cooling curve" recorders, for with a high chart speed and ten, fifteen, twenty or even thirty depressions per minute, it is possible to provide a very open, graphic curve showing the behavior of the specimen under treatment. It is also especially valuable in the automatic temperature controlling and recording apparatus, which the Thwing Instrument has recently developed.

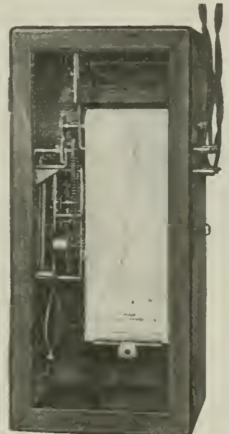


FIG. 2—RECORDING PYROMETER

A complete recorder ready for use is shown in Fig. 2.

## Notes

**The Chicago Section** of the American Chemical Society is compiling a census of the chemical laboratories, chemists, and chemically trained men within a radius of 40 miles of Chicago. Companies and individuals who maintain such laboratories or employ chemists are requested to communicate such facts to the Secretary of the Chicago Section, Mr. D. K. French, 2005 McCormick Bldg., Chicago, Ill.

**Electric Zinc Smelting.**—The American rights for electrothermic treatment of complex zinc ore are now controlled by Johnson Electric Smelting, Inc., Room 1802, 18 East Forty-first street, New York City. Byron E. Eldred, is president, W. McA. Johnson is first vice-president, Joseph Struthers second vice-president, and Phillip Mallery secretary and treasurer. The designs for a 10-ton unit are about finished, and the furnace is expected to be working in the fall.

**The Electrolytic Gas Company** has been organized by Mr. E. F. Platt, formerly connected with the Platt Iron Works of Dayton, O., and Mr. C. A. Kurz, Jr., of the Kurz Laboratories. This company has secured the western selling agency of the International Oxygen Company of New York, and it is the intention of the company to proceed with the installation of a number of electrolytic plants of the I. O. C. System for the production of oxygen and hydrogen in different parts of the country.

**The American Platinum Works**, at Newark, N. J., has issued a new illustrated catalog on their manufactures. The booklet contains also some timely hints on the care of platinum ware, as well as valuable tables of weights and measures.

**In drying apparatus** of the type made by the Ruggles-Coles Engineering Company, New York, the exhaust gases are at a temperature of about 100° F., so that an exhaust fan may be used. By increasing the speed of the fan an increased capacity of the dryer may be obtained in almost direct proportion. Additional interesting information about dryers is contained in a catalog recently issued by the company.

**The Patterson Foundry and Machine Co.** states that, contrary to the general belief of the existence of a general business depression, they have been so rushed with orders as to find it necessary to build an addition to their Upper Works at East Liverpool, Ohio. They are also now considering the increase of the capacity of their Lower Works and an increase in their structural and steel plate department. All of the Patterson products are made entirely in the Patterson shops, including all parts of all machines. To take care of their rapidly growing trade in the East they will open shortly a fully equipped New York office. Mr. Edward W. Lawler, formerly with the Abbe Engineering Company for a number of years, will be in charge of this office and represent the Patterson Foundry & Machine Company in New York and adacent territory.

**Two new white-metal alloys** of silver and aluminum, known as "argental" and "macadamum," are said to possess properties that make them superior to other metals for certain uses. They take a high polish, do not tarnish or corrode, and can be cast or rolled. The alloys are marketed by the North American Selling Company, 120 Liberty street, New York City.

**Baker & Company, Inc.**, of Newark, N. J., have recently added a new factory and office building to their plant. The structure will be devoted to the manufacture of platinum wire, sheet and tubing, as well as crucibles and dishes for chemical purposes. Extensive additions are also planned for the refining and research departments which will occupy the building formerly devoted to the manufacturing department.

**The Check to Dampness** is the title of an attractive edition of their "Red Book" just issued by Toch Brothers, 320 Fifth Avenue, New York City. It contains valuable data for the architect, engineer and builder who wishes to keep posted on the latest developments in materials for the preservation and decoration of every type of building construction. Toch Brothers for years have been inventors and manufacturers of technical and scientific paints, enamels, varnishes, etc., and this book is replete with data pertaining to materials which are proof against all destructive agencies—acids, alkalies, electrolysis, locomotive fumes, etc., and, in addition, contains authoritative data on the integral waterproofing of dry docks, tunnels, swimming pools, reservoirs; also the treatment of cement floors in warehouses, automobile plants, loft buildings, power houses, public and private buildings.

**The Badger Chemical Diary** for 1914, issued by the E. B. Badger & Sons Company of Boston, Mass., contains in a very convenient form besides the usual diary, maps of different sections of the United States and illustrated notes on various products of this firm, such as stills, evaporators, vacuum fans, dryers, autoclaves, lead and silver-lined apparatus, etc. Some useful tables are added.

**Coal briquets** to the amount of 181,859 short tons, valued at the plants at $1,007,327, were manufactured in 1913, according to Edward W. Parker, of the United States Geological Survey. The figures for 1913 show a decrease of 17 per cent in the tonnage of briquets manufactured, but an increase of over $5\frac{1}{2}$ per cent in value over the figures for 1912. Seventeen briquetting plants were in operation during the year, eight in the Eastern States, five in the Central States, and four on the Pacific coast. Seven of these plants used anthracite culm or "fines," five used bituminous or semi-bituminous coal, two used carbon residue from oil-gas works, and the others used mixed coals. Coal-tar pitch is the principal binder employed, eight plants using it. Patented binders were used at five plants.

# Metallurgical and Chemical Engineering

A Consolidation of ELECTROCHEMICAL AND METALLURGICAL INDUSTRY and IRON AND STEEL MAGAZINE

VOL. XII NEW YORK, JUNE, 1914 No. 6

PUBLISHED MONTHLY BY THE
McGraw Publishing Company, Inc.
JAMES H. MCGRAW, President.
C. E. WHITTLESEY, Secretary and Treasurer.
239 West 39th Street, New York.
TELEPHONE CALL, 4700 BRYANT.
CABLE ADDRESS, METCHEM, NEW YORK.

WESTERN OFFICE.................421 Boston Bldg., Denver, Colo.
CHICAGO OFFICE.........................Old Colony Building
PHILADELPHIA OFFICE................Real Estate Trust Building
LONDON OFFICE............Hastings House, Norfolk St., Strand

E. F. ROEBER, PH.D., Editor.
H. C. PARMELEE, Western Editor.

J. M. MUIR, Manager.

*Yearly subscription price for United States, Mexico and United States dependencies, $2.00; for all other countries, $2.50. (European exchange, 10 shillings, 10 marks, 12.50 francs.)*

Copyright, 1914, by the McGraw Publishing Company, Inc.

Entered as Second-Class Matter at the Post Office at New York, N. Y., under the Act of Congress, March 3, 1879.

NEW YORK, JUNE, 1914

EDITORIAL:

Paul Héroult .................................... 361
Iron and Steel Output in 1913.............................. 361
Sweeping Decision in Flotation Litigation............. 362
High-Frequency Spectra of Elements and the Structure of matter .......................................... 363

READERS' VIEWS AND COMMENTS:

A Suggestion of a New Method for Determining the Temperature of Ingots. ByJohn G. Homan.............. 364
Power Problems in Electrochemistry. By R. M. Chatterton ............................................ 364
The Heat Treatment of Steel—Results Obtained by Spring Makers and Steel Works Treatment. By William D. Mainwaring ............................................ 365
The Western Metallurgical Field.............................. 365
The Iron and Steel Market.................................... 367
American Electrochemical Society Niagara Meeting......... 368
Iron and Steel Institute........................................ 368
Is There a Complex Ore Problem —II...................... 369
Program of Troy Meeting of American Institute of Chemical Engineers ............................................ 376
Light from Unconsumed Electrodes. By A. Vosmaer....... 377
Factors Affecting the Cost of Copper...................... 379
Tropenas Converters vs. Electric Furnaces for the Manufacture of Steel Castings. By G. Muntz.................. 379
Award of the Willard Gibbs Medal to Ira Remsen.......... 381
The Late Paul Héroult.......................................... 382
A Study of the Annealing Process for Malleable Castings. By Oliver W. Storey......................................... 383
Wheeling Creek Mine Explosion.............................. 389
Determination of Carbon in Iron and Steel. By W. D. Brown 390
A Convenient Method for Handling Chemical Solutions in Quantity. By C. C. Phelps.................................. 391
The Development of Modern Cyanide Practice. By C. M. Eye 392
Sixth International Congress of Mining, Metallurgy, Engineering, and Economic Geology, London, 1915............. 392
Development of Alaska.......................................... 394
The British Aluminium Co...................................... 394
Scotch Shipbuilding ............................................ 394
Blast Furnace Stoves. By J E. Johnson, Jr................. 395
Recent Chemical and Metallurgical Patents.................. 412
Synopsis of Recent Chemical and Metallurgical Literature.. 414
Notes on Chemistry and Metallurgy in Great Britain........ 415
The Lavoisite System of Generating Oxygen................. 417
Accelerators for Gasoline Gas Plants. By J. Barton...... 419
The Vaporization of Jacket Water............................ 420
Electric Furnace Regulators.................................. 421
The Latest Slide-Rule Improvement........................... 423
Compressing Air and Gases.................................... 423
Prospects of Electric Zinc Smelting in British Columbia.. 425
Digest of Electrochemical U. S. Patents (Electroplating).. 425
Personal ........................................................ 425
Obituary ........................................................ 426
Book Review .................................................... 426

## Paul Heroult

Out of the international group of the few great men who are the creators of modern industrial electrochemistry, Paul Héroult has gone into eternity. A sketch of his life is given elsewhere in this issue, but no such sketch can indicate the elemental greatness of the man whose loss we mourn. Héroult could have become a great mechanical engineer, but destiny made him a pioneer of electrochemistry. People wonder why Héroult and Hall should have found the same process of reducing aluminium simultaneously and independently in France and America. They might just as well wonder why it rains simultaneously in two places, if the air is oversaturated with water vapor in both. Humanity was ripe for the birth of industrial electrochemistry and the intellectual atmosphere was oversaturated with the ideas of its possibilities. Destiny's problem was to find the men who would be the nuclei of condensation. Héroult was one of them and in the history of mankind he will live forever as the pioneer of the electrometallurgy of aluminium and steel.

But in destiny's hands it is the man as man that counts. And those who knew Héroult best, loved him most as mere man. For ourselves we can say no more than that this journal has lost in him one of its oldest and truest friends. For all of his many friends all over the world we know we can say that though Héroult has gone, the memory of his genial personality will remain an everlasting inspiration.

## Iron and Steel Output in 1913

With the appearance in the past fortnight of additional statistics of steel production in 1913 some interesting comparisons can be made. The 1913 statistics as far as reported are embodied in the following table, the figures referring to gross tons except in the case of nails:

| | 1912. | 1913. | Change. Per Cent. |
|---|---|---|---|
| Pig iron ........... | 29,726,937 | 30,966,152 | + 4.16 |
| Rails ............... | 3,327,915 | 3,502,780 | + 5.26 |
| Structural shapes .. | 2,846,487 | 3,004,889 | + 5.55 |
| Rods ............... | 2,653,553 | 2,464,807 | — 7.12 |
| Wire nails (kegs)... | 14,659,700 | 13,559,727 | — 7.50 |
| Cut nails (kegs).... | 978,415 | 842,038 | —13.90 |

The outstanding feature in the comparison is the decline in rod production. While rods are used for the production of chain, the great bulk of the output is consumed in the manufacture of wire so that the decline in rod tonnage may be regarded as a decline in the production of wire. The production of wire nails, it may be noted, decreased in substantially the same ratio as the production of rods. The greater decrease in cut nail output represents no new trend, for the cut nail output has decreased nearly every year since the maximum was reached in 1886, or since the wire nail began to come into vogue.

Fifteen years ago the statisticians were making predictions that eventually the production of rods would exceed the production of rails. It was an interesting thing to say, and the bare figures appeared to furnish adequate support. The production of rods had increased from 279,769 tons in 1888, the first year for which statistics were gathered, to 1,071,683 tons in 1898, an increase of 282 per cent. Rails had made the poor showing of being unable to surpass the tonnage made as far back as 1887. Those statisticians, however, overlooked certain things. Fully one-third of the 1898 production of rods went into nails, and this represented quite largely a displacement of the cut nail by the wire nail, a displacement then almost completed. They overlooked also that wire products were purchased and consumed by the people for their ordinary daily requirements, hence the five-year industrial depression from which the country was emerging had not very seriously curtailed wire consumption. On the other hand, the railroads were very poor. A large percentage were just emerging from receiverships. In 1899, a year of great activity in iron and steel, the rod production actually decreased, whereas rail production made a new record, at last passing the tonnage of 1887. From 1899 to 1906 rail production increased 78 per cent while rod production increased 84 per cent., rods, therefore, making hardly any gain over rails. Since 1906 there has been some good reason, however, for repeating the old prediction, since from 1906 to 1913 rail production decreased 12 per cent., whereas rod production increased 32 per cent., and in 1913 rods amounted to 70 per cent., as large a tonnage as rails.

Reverting to the comparison between 1912 and 1913, it is remarkable that rails and structural shapes made gains slightly greater than were made in pig iron, and rods, a light product, showed a loss, for the steel trade philosophy of recent years has been that the gains in tonnage were likely to be made by the light products, particularly in years in which financial conditions were not especially favorable to the launching of big enterprises. These big enterprises involve the consumption of structural shapes very largely, and it is commonly held that in no year since 1906 have conditions been nearly as favorable as in that year for the financing of such things. Nevertheless, we find that the production of structural shapes increased 41.9 per cent., while the production of pig iron increased only 24.3 per cent. Given such an expansion in new construction and the launching of big enterprises as is to be expected some day, the tonnage of structural shapes promises to show further large gains. In 1913 they fell only 14 per cent. under rails, when 15 or 20 years ago their tonnage was almost insignificant.

## Sweeping Decision in Flotation Litigation

The United States Circuit Court of Appeals for the ninth circuit, sitting at San Francisco, handed down on May 4 a decision in the case between James M. Hyde and Minerals Separation, Ltd. The latter had brought suit against the former as infringing Minerals Separation flotation patents, and had secured a favorable decision in the lower court. The Court of Appeals reversed this decision and upset Minerals Separation patents on concentration by flotation.

The decision is of wide interest and has been awaited impatiently by many metallurgists who were concerned in one way or another with the future of flotation in this country, and who viewed with apprehension the prospect of a monopoly in that new and promising branch of metallurgy.

The language of the court is forcible, clear-cut and unequivocal and the point of view on which the decision is based is interesting. The basis of novelty and invention claimed by Minerals Separation lay in the formation of a froth containing concentrates produced by agitation of pulverized ore in water, by the action of oil in quantity less than 1 per cent of the ore treated. The froth and the minute quantity of oil were the main points. The court reviewed the patents in the art beginning with those of Haynes (British) in 1860, and Everson's (U. S.) in 1886, and found each of the steps in Minerals Separation's process "fully described in more than one of the patents of the prior art, with the single exception of the reduced quantity of oil." The mere formation of a froth by agitation was held to be anticipated in the prior art.

The attitude of the court regarding the small quantity of oil used in the Minerals Separation process was that reduction in the amount of oil required for flotation was only a logical development in metallurgical economy and efficiency such as any progressive concern would bring forward in the course of its investigations. The mere use of a smaller quantity of oil than in other processes is, therefore, held not to be sufficient to constitute invention, for this difference is one of degree and not of kind. To hold such a claim valid would be "to take from others the right to use oil economically." Quoting from another decision the Court said: "A change in form, proportions or degree, doing substantially the same thing in the same way by substantially the same means, with better results, is not such invention as will sustain a patent"; and on its own behalf it held "that to sustain the appellee's (Minerals Separation) patent would be to give the owners thereof a monopoly of that which others had discovered."

There are two courses yet open to Minerals Separation before it may consider its case finally lost. It may seek a review of the decision by the U. S. Supreme Court directly or it may endeavor to get a different decision in another circuit of the Court of Appeals and if successful, bring the case before the Supreme Court for final judgment. Either course is beset with very great difficulties. It may be expected, however, that Minerals Separation will not accept defeat until it has exhausted every possibility of carrying the case to the highest court, just as it has done successfully in its Australian litigation. It is equally true that it will find ready adversaries along the way, eager to break the monopoly which undoubtedly has deterred some big operators from openly adopting flotation.

However, with the patent statutes once definitely and finally declared, we believe the flotation process will be widely used in this country and prove especially valuable in reducing mineral waste.

---

## High-Frequency Spectra of Elements and the Structure of Matter

It is well known that when a substance, which for definiteness may be a simple elementary substance, such as aluminium, is powerfully heated, it emits radiation with a certain range of variation in regard to frequency or wave-length. Such wave-lengths may extend from about 0.1 μ to 30 μ or more, the symbol μ designating a micron, or the millionth of a meter. The range of the visible spectrum is known to be roughly from 0.4 μ to 0.8 μ.

When an elementary substance is supported in a vacuum-tube and is made a target for electric discharges, the substance emits X-rays. For a long time it was supposed that X-rays had no wave-length; but recent researches have shown that they consist of two types of radiation, one of which is irregular or non-rhythmic, so as to have no wave-length; while the other is regular and rhythmic, possessing a wave-length. This X-ray wave-length is, however, very much shorter than that of the ordinary incandescence spectrum. It may range from 60 μμ to 800 μμ where the symbol μμ is a micro-micron, or the millionth of a millionth of a meter. It is only possible, at present, to measure these extraordinarily small wave-lengths, by means of reflecting mirrors of molecular type. That is to say, the polished reflectors of ordinary light are far too coarse-grained, and crystalline surfaces of natural cleavage have to be used.

In recent numbers of the Philosophical Magazine, Mr. H. G. J. Moseley has described some important experimental researches on the frequencies and wave-lengths of X-rays emitted from targets of different substances employed successively as the cathode in an X-ray tube. The generated X-rays, after passing through a small slit, are allowed to fall upon the surface of a crystalline reflector. The incident beam of X-rays emerges from the crystalline surface in certain definite directions, when the angle of incidence is just right for rays from the particular substance under investigation. The reflected beam is caught on a photographically sensitive plate, and leaves a record line on its surface after the plate has been developed.

The whole experimental system has ordinarily to be worked in vacuo, as the air would absorb the faint reflected beam.

It is shown that each elementary substance has a definite X-ray frequency of emission, such that, if the square-root of the frequency is taken as abscissas, the various elementary substances plot along a straight line in order of atomic weights. Thus, every element from aluminium to gold, possesses a certain whole number N, which determines its X-ray spectrum, and which Mr. Moseley calls the "atomic number" of the element. It is noticeable that whereas the atomic weight of an element is not a whole number or integer, the X-ray atomic number is claimed to be in all cases a simple integer, commencing with 13 for aluminium, and ending with 79 for gold, with only three gaps, which are suggested to belong to elements as yet undiscovered. Moreover, the atomic number N is identified with the number of positive units of electricity in the atomic nucleus of the atom. The order of succession of the atomic numbers is, with a few exceptions, the same as the order of atomic weights, and the exceptions appear to exist at points in the series where the chemical properties of the elements disagree with the order of atomic weights. Expressed in another way the squares of the successive numbers are proportional to the X-ray spectrum frequencies of the various elementary substances.

The observations also indicate that in the elements investigated, the angular momentum of an electron in any elementary atom is the same. That is, the product of the square of the orbital radius of an electron, into its angular velocity about the center of the atom, is the same for all electrons and atoms. If this result can be verified, it will constitute a remarkable generalization concerning the constitution of matter. It supports the hypothesis that each negative electron pursues an orbit about the positive atomic nucleus, and is held in equilibrium at that orbital radius where the inwardly directed electric attraction balances the outwardly directed contrifugal force. The attractive force on each planetary electron would thus be a purely electrostatic force, enormously greater than that of gravitation; while the repulsive force would be a purely magnetic force, not differing except in magnitude from the force of inertia in the world immediately perceived by the senses.

There is thus presented experimental evidence for the belief that the atoms of different elementary chemical substances differ fundamentally, and in the most simple order of classification, by the number of positive electrons forming their respective nuclei. Each atom may be regarded as a sun-and-planet microcosmic system, in which the positive nucleus corresponds to the sun and the gyrating negative electrons to the planets. Whereas in the cosmic universe, planets differ in size and in angular momentum, in the microcosmic or atomic universe, planets all have the same size, and also the same angular momentum. Oscillations in the orbital paths of electrons due to cathode-ray impacts, give rise to the high-frequency spectrum oscillations of the atom; whereas oscillations between molecules produce the lower-frequency spectrum oscillations that give us the colors of the rainbow.

# Readers' Views and Comments

## A Suggestion of a New Method for Determining the Temperature of Ingots

*To the Editor of Metallurgical & Chemical Engineering:*

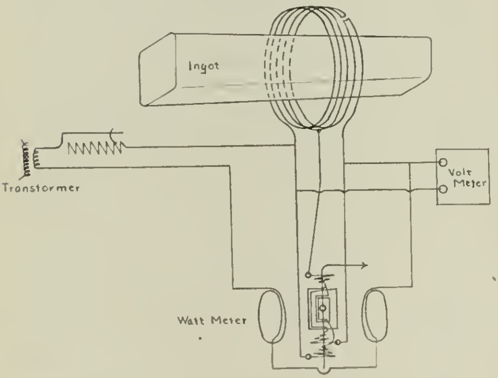
SIR:—Considerable saving in power required to roll steel and other meals could be made if a suitable means were devised to control the temperature of the object to be rolled. No doubt improved quality of the finished metal might also result if uniform methods could be practised.

In the quenching of steel objects such as tools, permanent magnet forms, etc., valuable data might be obtained if the time-temperature curve were readily obtainable.

The value of an idea which might result in the accomplishment of satisfactory temperature determination, is the excuse for these remarks.

The determination of temperature of a steel ingot, for instance, is accomplished best at present probably by the use of thermocouples, though in certain cases it might be possible to use the electrical resistance method.

Using the thermocouple it is practicable to apply same to the ingot surface only, but this surface is covered with an oxide coating more or less variable in thickness so that the indications produced by the thermocouple are hard to correct for average temperatures within the ingot. Certain methods of heating ingots would also influence the correction factor to be applied to the surface indications; the centre of the ingot may or may not be hotter than the surface. Considerable time is required when a thermocouple is used due to its low heat conductivity as a rule. Heat is also abstracted from the place of contact.



ELECTRIC METHOD FOR DETERMINING TEMPERATURE OF INGOTS

The resistance method requires contacts with the heated object, which are difficult to obtain as desired; the method is slow also therefor.

Electrical resistance, magnetic hysteresis and permeability are functions of the temperature. Suppose a coil be provided (as indicated in the sketch), through which an alternating current was caused to flow, the e.m.f., wave form, frequency, etc., being maintained constant. The ingot whose temperature was required might be introduced into the field of this coil and the sum of the eddy current and hysteresis energy losses read from the wattmeter. The $I^2R$ loss of the coil could be automatically subtracted from the total energy loss so that the wattmeter would indicate energy manifestations within the ingot only. A differential wattmeter might be used as indicated, and this procedure should obviate the error which would otherwise result due to resistance change of the coil with heat.

The indication of the wattmeter would be instantaneous and could be readily obtained in temperature figures with a suitable calibration curve.

The calibration curve might be absolute or empirical, but certainly it would obtain only for a given ingot of fixed size and practically fixed composition. The position of the coil with respect to the ingot would also require to be practically fixed.

This method would require no contacts with the heated object other than those of the charging machine or manipulating device ordinarily used.

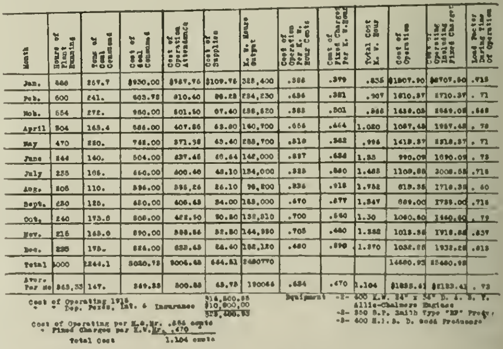
JOHN G. HOMAN.

Follansbee Brothers Company,
Follansbee, W. Va.

## Power Problems in Electrochemistry

*To the Editor of Metallurgical & Chemical Engineering:*

SIR:—I have been much interested in reading the papers on the power problems in the electrolytic deposition of metals in your February issue, page 91, and your May issue, page 328.



| Month | Hours of Plant Running | Tons of Coal Consumed | Cost of Coal Consumed | Cost of Operating Attendance | Cost of Supplies | K. W. Hours Output | Cost of Operation Per K. W. Hour Cents | Cost of Fixed Charges Per K. W. Hour | Total Cost K. W. Hour | Cost of Operation | Cost of Operating Including Fixed Charges | Load Factor During Time of Operation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan. | 686 | 267.7 | $930.00 | $767.76 | $109.76 | 328,400 | .388 | .379 | .835 | $1807.90 | $2707.90 | .718 |
| Feb. | 600 | 241. | 603.78 | 810.40 | 96.28 | 234,230 | .636 | .381 | .907 | 1610.37 | 2710.37 | .71 |
| Mch. | 654 | 272. | 960.00 | 601.50 | 67.40 | 238,620 | .588 | .301 | .968 | 1638.08 | 2549.08 | .668 |
| April | 304 | 163.4 | 586.00 | 407.86 | 63.80 | 160,700 | .656 | .464 | 1.020 | 1057.48 | 1957.48 | .70 |
| May | 470 | 220. | 742.00 | 371.38 | 43.40 | 288,700 | .510 | .382 | .996 | 1613.37 | 2513.37 | .71 |
| June | 344 | 140. | 504.00 | 437.48 | 40.64 | 142,000 | .687 | .634 | 1.33 | 990.09 | 1890.09 | .73 |
| July | 255 | 106. | 660.00 | 400.40 | 48.10 | 134,000 | .825 | .660 | 1.488 | 1109.88 | 2008.88 | .718 |
| Aug. | 206 | 110. | 596.00 | 595.26 | 26.10 | 96,200 | .836 | .916 | 1.752 | 819.36 | 1719.36 | .60 |
| Sept. | 280 | 125. | 480.00 | 406.48 | 24.00 | 183,000 | .470 | .877 | 1.347 | 889.00 | 1789.00 | .718 |
| Oct. | 240 | 173.8 | 806.00 | 422.50 | 30.80 | 132,810 | .700 | .660 | 1.30 | 1060.60 | 1960.60 | .79 |
| Nov. | 216 | 165.0 | 890.00 | 388.56 | 32.80 | 144,930 | .705 | .480 | 1.382 | 1013.36 | 1918.86 | .837 |
| Dec. | 236 | 175. | 824.00 | 633.48 | 24.40 | 162,120 | .480 | .890 | 1.370 | 1032.86 | 1932.26 | .813 |
| Total | 4000 | 2244.1 | 8020.72 | 9006.48 | 644.83 | 2480770 | | | | 14600.95 | 25400.95 | |
| Aver. Per Mo | 363.33 | 147. | 849.23 | 500.88 | 63.73 | 190066 | .634 | .470 | 1.104 | $1833.41 | $2133.41 | .73 |

Cost of Operating 1918 $14,600.85
" " Dep. Taxes, Int. & Insurance $10,000.00
$25,600.85

Cost of Operating per K.W.Hr. .634 cents
" Fixed Charges per K.W.Hr. .470 "
Total Cost 1.104 cents

Equipment -2- 400 K.W. 24" x 36" D. A. S. T. Allis-Chalmers Engines
-2- 350 H.P. Smith Type "BP" Prod'rs
-2- 400 H.P. S. D. Gas Producers

RECORD OF ONE YEA' COMMERCIAL OPERATION

I am enclosing a blue print showing a recapitulation of a year's log sheet from an 800-kw gas power plant operating on bituminous coal that costs $3.50 per ton. By checking the various items in this table carefully you will note that with uniform load factor somewhere near the capacity of the plant and when in twenty-four hour operation power could be developed at a very low figure in such a plant. The cost data in this recapitulation are carefully kept, and all of the expenses, including fixed charges, incident to the operation of the plant, are figured in. I believe that such equipment as this could be advantageously used in the electrochemical industry. I note from the discussion of the various papers that there is sufficient waste heat from the reverbatory furnaces in these plants to furnish all the steam necessary for heating purposes. Considerable heat can also be recovered from the waste from the gas engines if the waste from the furnaces is not sufficient.

Regarding Mr. Vom Baur's comments on the possibility of oil engines to operate on Mexican fuel oil, I will say that Diesel engines in Texas will not operate successfully on this fuel. This can be verified on the ground by any one interested in the subject. There are probably more Diesel engines in Texas than in any other part of this country and they are operating on high-grade oils.

R. M. CHATTERTON.

Smith Gas Power Co., Lexington, Ohio.

---

### The Heat Treatment of Steel—Results Obtained by Spring Makers and Steel Works Treatment

*To the Editor of Metallurgical & Chemical Engineering:*

Sir:—The question of heat treatment is now attracting the attention of producer and consumer to a degree almost unparalleled in the field of steel manufacture. In order to get satisfactory results, it must be approached in a practical and scientific manner, because if the consumer carries his specifications to an extreme extent, it will be almost impossible to secure steel from the producers.

An extensive research was carried out by the author in 1910 upon a carload of steel that had been rejected by a prominent spring manufacturer, who claimed that it could not be "tempered" even in water. Upon receipt of the carload of steel, an analysis was made for carbon which was found by combustion to be 0.95.

The question arose at once whether there was some hidden cause, why the steel could not be tempered as the spring makers wrongly called it, whether there was something wrong with their methods or something wrong with the combustion apparatus and supplies used, whereby high-carbon results were being obtained. The last question was attacked first and it was finally found, by running checks upon known standards, that the apparatus, supplies and results obtained were correct.

The next problem was to answer the claim of the spring maker that this steel could not be "tempered," or rather hardened, as it should be called, in water. Several pieces were selected at random from the car, heated in a mill furnace and hardened by two methods in a bosh of water, both lots of steel being heated to a like degree. In the first method the steel was quenched as soon as it was drawn from the furnace, in the second method the steel was allowed to cool to a point slightly over the recalescence point and then quenched, this being done to approach as nearly as possible the method followed in some manufacturing plants.

In both cases by dropping the steel upon the mill tracks, it was found to be as brittle as glass. The first lot quenched had an extremely fine grain, and the second had a coarse structure on account of the crystals having time to grow, before the steel was quenched. This answered the statement that the steel would not harden in water.

Upon this report being turned into the office, it was put up to the writer to find out just what was wrong. It must be taken into consideration that this steel was an ordinary carbon steel and, therefore, any kind of treatment was good enough, from the viewpoint of the manufacturers.

The heat numbers shown in table 1 were selected for the extended research, several billets being rolled into $1\frac{3}{4}$ x $\frac{1}{4}$ square edge flats.

TABLE 1—HEATS SELECTED

| Heat Nos. | Shippers Carbon | Works Analysis |
|---|---|---|
| 1490 | 0.96 | 1.09 |
| 1493 | 0.92 | 0.90 |
| 1524 | 0.96 | 0.94 |
| 1527 | 1.00 | 1.05 |
| 1538 | 1.02 | 1.00 |
| 1540 | 1.12 | 0.94 |
| 1541 | 1.06 | 1.04 |
| 1550 | 0.90 | 0.90 |
| 2565 | 1.08 | 1.03 |
| 2582 | 0.90 | 0.90 |

Bars selected were marked Lot Nos. 1 and 2. Bars from Lot No. 1 were nicked on one end in order to make a fracture after tempering. In order that the test should be a practical one, a rolling-mill furnace was selected after it had cooled down from its day's run. The temperature was then brought up to the desired point, the bars put in and each one heated uniformly and quenched in oil, the furnace was then cooled down and the bars placed back and the temper drawn, until the oil just flashed.

It must be taken into consideration that this method was followed in order to duplicate as closely as possible the spring makers' methods, then employed.

These bars were then tested in an oil hydraulic spring tester having an upward thrust, they being placed on two knife edges on tester tables, the pressure being taken up in the center by means of another knife edge in head of tester. In order to get a sensitive measure of the permanent set, the bars had been formed with a camber of one-half inch.

Lot No. 1 was tested at a modulus of rupture of 130,000 lbs.; Lot No. 2, 140,000 lbs.

TABLE 15—RESULTS OF TESTS
130,000 lbs.

| Heat | Lot | Permanent Set | Fracture | Heat | Lot | Remarks |
|---|---|---|---|---|---|---|
| 1490 | One | None | | 1490 | Two | Lot No. |
| 1493 | " | " | All | 1493 | " | one heat |
| 1524 | " | " | | 1524 | " | 2565. |
| 1527 | " | " | uniform, | 1527 | " | carried |
| 1538 | " | " | | 1538 | " | up to a |
| 1540 | " | " | fine | 1540 | " | modulus |
| 1541 | " | " | | 1541 | " | of 150,000 |
| 1550 | " | " | and | 1550 | " | Permanent |
| 2565 | " | " | | 2565 | " | set 1/16" |
| 2582 | " | " | silky | 2582 | " | |

Loads applied 5 times

Feeling safe after such a test, rollings were made from these heats and shipped. An awful holler was raised, it being emphatically stated that this steel could not be tempered by the regular shop methods and that a special treatment had to be designed.

After these reports were turned in, it was decided that the trouble was a case of six on one side and half a dozen on the other, both the steel and spring manufacturers being at fault.

The conclusion drawn from the research was that in order to get satisfactory results from any type of steel, carbon or alloy, it was necessary to give the steel a proper treatment. Also that the method used for manufacturing the steel leaves its effect upon the steel so produced.

WILLIAM D. MAINWARING.

866 Rockefeller Building, Cleveland, Ohio.

---

## The Western Metallurgical Field

### Carnotite Concentrators for Colorado

Essentially two methods of concentrating carnotite ores have been developed as the result of experimentation during the past few years. Ordinary methods of concentration based on difference in specific gravity of minerals will not suffice, for the uranium-vanadium mineral exists as a thin coating or sand grains and produces a slime or powder when removed from the gangue. Hence special methods of separation and concentration have been devised—both wet and dry. The general principle of these methods has been made public by the Bureau of Mines in Bulletin 70[1], and details of a wet process also have been published in this journal.[2]

Until recently, however, no attempt to concentrate these ores has been made on a commercial scale, although the economic reasons for so doing have always been recognized. The Standard Chemical Company, of Canonsburg, Pa., is to be the first in the

---

[1] See this journal February, 1914, page 89.

[2] Article by Siegfried Fischer, October, 1913, page 586.

Colorado district to build concentrating plants. This company owns a large number of claims and is probably the largest single producer of carnotite in this country. It has figured prominently in the "radium hearings" before congressional committees, and has been concerned over the proposal of the Government to produce radium; but with the Government's position made clear by Dr. Joseph A. Holmes,[3] undue anxiety on this score may now be allayed.

It is reported that the Standard company will erect several concentrating plants at different points in southwestern Colorado: one near Naturita, 60 miles west of Telluride; a second in the East Paradox district, and a third in the McIntyre field. A fourth may be built in Utah to handle ore from the southeastern part of that state. The immediate construction of the first mentioned is assured, and machinery for it has been purchased.

No announcement has been made as to the details of the process to be used, but the general principles can be surmised from the references given. It is known, however, that Mr. Warren F. Bleecker, now on the metallurgical staff of the company, developed concentrating processes for carnotite while making independent researches on uranium and vanadium ores in Colorado before taking his present position, and it is probable that his methods will be adopted on a commercial scale in the new plants.

### Bureau of Mines

The third annual report of the Director of the Bureau of Mines deals with the aims and objects of the Bureau, outlines its needs and gives a summary of work accomplished in its various departments. Some of the items are of special interest to the metallurgical industry.

During the fiscal year 1913 a study was made of milling methods in the lead-zinc districts of Missouri, Oklahoma, Arkansas, Wisconsin and Illinois. The investigation showed the possibility of practicable savings of ore now wasted. This work is to be continued and published in a bulletin.

The electric smelting of ores was under investigation at Pittsburgh. One problem studied was the possibility of using crude oil as a reducing agent, while another was the smelting of copper concentrates. In non-ferrous metallurgy the following points were considered: the possibility of recovering the iron in slag; of producing ferro-silicon from slags; of recovering sulphur from sulphide ores, and of discovering some suitable collector other than lead and copper for precious metals in smelting practice.

A study of sampling and assaying methods was under way during the year. This included the sampling of ores and metals, molten and solid alloys, charges in the furnace, and solid materials. It is hoped that the investigation will give methods that can be accepted as standard by producers and operators.

The work on smelter fumes and gases was conducted at San Francisco. This had special reference to the recovery of valuable constituents of fumes which are now wasted. New uses have been sought for sulphur, arsenic, bismuth, selenium and tellurium. Formal cooperation with the Bureau in advancing the work has been given by the Anaconda smelter in Montana and the Selby in California. A special report on the methods now in use or being tested for prevention of damage by smelter smoke is to be made by Mr. C. H. Fulton.

Other interesting studies have been under way in reduction of mineral waste, prevention of losses in making non-ferrous alloys, utilization of domestic fuller's earth, silica and minerals used in the making of refractories.

### Societies and Organizations

The Utah members of the American Institute of Mining Engineers have been organizing a local section of the parent body, preparatory to formulating plans for entertainment of the Institute at the meeting in Salt Lake City in August. Mr. R. C. Gemmel, manager of the Utah Copper Co., and Mr. Ernest Gayford, of the General Engineering Co., have been active in the work. The Utah engineers have asked the Nevada members of the Institute to join in the organization, which may be known as the Utah-Nevada section, provided the Nevada members acquiesce. The Salt Lake meeting of the Institute promises to be as successful as was the Butte meeting, and it is certain that Utah hospitality will make the affair most pleasant as well as profitable.

The International Engineering Congress has announced the topics under which the section on Mechanical Engineering will group the papers presented. Many of these topics are of direct interest to the metallurgical fraternity, as they deal with metal working, industrial management, power plants, etc. At present the Congress has received enrollments and subscriptions from 42 foreign countries. The subscriptions from the membership of the five American engineering societies, under whose auspices the Congress is held, is not so gratifying, and amounts to only 3.7 per cent of the total subscriptions. Procrastination on the part of American engineers is handicapping the work of the Congress, and they are urged to subscribe at an early date.

### Flotation Litigation

In a recent circular to stockholders, the Ore Concentration Co., Ltd. (Elmore process), makes the following statement relative to its action for infringemen against the Sulphide Corporation, Ltd., in New South Wales.

"The judgment, which was delivered on the 6th of March, is very disappointing in one respect, inasmuch as the process as carried out by the defendants is held not to be an infringement of the patent sued under. On the other hand, it is satisfactory that a certificate of validity of this patent will be granted to us by the Court, and that all the alleged anticipations set up against it by the defendants have been swept aside. The position therefore at the present moment is that we have not proved infringement by the defendants in the above case, but we have established that our own patent is good and valid."

### Anaconda-International Consolidation

Announcement is made that the Anaconda Copper Mining Co. has purchased the assets and business of the International Smelting & Refining Co. The International was organized several years ago, and its technical operations have been directed by men formerly in the employ of the Anaconda company. It has a lead and copper smelter at Tooele, Utah, and a refinery near Chicago. Anaconda company capitalists have been heavily interested in the International company, and the consolidation causes little surprise in view of the close arrangements formerly existing between the two companies.

### Company Reports

Operations at the plant of the **Old Dominion Copper Mining & Smelting Co.**, Arizona, during 1913, were carried on under adverse conditions, due mainly to congestion in the mining department caused by enlarging underground stations and cutting skip pockets. The construction of a new concentrator and the experiments that were carried on during the year made economical operation of the old mill a difficult matter. The new mill probably will not be in operation before August next.

---

[3] See this Journal May, 1914, page 331

| Ore Extraction: | Dry Tons | Average Copper, Per Cent |
|---|---|---|
| Smelting ore | 120,257 | 6.85 |
| Concentrating ore | 47,785 | 3.56 |
| Silica lining | 1,919 | 3.37 |
| Total and average | 169,961 | 5.88 |

| Concentration: | Dry Tons | Per Cent Copper | Cost Per Ton |
|---|---|---|---|
| Company ore | 47,972 | 3.56 | ...... |
| Custom ore | 102,231 | 3.76 | ...... |
| Total and average | 150,203 | 3.70 | $0.878 |

Concentrating cost in 1912 was only $0.753 per ton. The increase in 1913 was due chiefly to abnormally heavy repairs in the mill, and reduced capacity caused by construction work. Experiments on flotation by the Minerals Separation process have been under way to determine the results that may be obtained by thus treating fine slime on which a heavy loss has been sustained in the past.

| Smelting and Converting: | |
|---|---|
| Tons new charge smelted | 300,926 |
| Cost per ton | $2.629 |

The cost was higher than in 1912 ($2.304) due to increased coke consumption, higher wages and extraordinary improvements. The smelting of flue dust was discontinued for three months, but was resumed when the furnaces showed no improvement in running without this material in the charge.

| | |
|---|---|
| Pounds blister copper produced | 30,811,141 |
| Pounds fine copper produced | 30,572,863 |
| Cost converting per ton fine copper | $9.19 |

The old acid-lined converters have been replaced by the Great Falls type of basic-lined converter, and the results are satisfactory. The cost of converting in 1912 was $9.45 per ton of fine copper. The saving effected in 1913 was derived mainly from the decreased cost of relining, which fell from $2.23 per ton of copper in 1912 to $0.25 in 1913. The cost of improvements amounting to $24,732 is included in the cost for 1913. The total cost of producing fine copper was 9.70 cents per pound.

The annual report of the Miami Copper Co., Arizona, for 1913, contains the following items of metallurgical interest. Experimental work conducted in one of the six sections of the mill has shown that the plant can be remodelled to handle at least 4000 tons of ore per day. Various mill improvements resulted in a lower cost of treatment, which is given below:

| | Per Ton |
|---|---|
| Crushing | $0.20806 |
| Concentrating | 0.18852 |
| Handling tailing and concentrates | 0.05880 |
| Water for concentrating | 0.08553 |
| Betterments | 0.03134 |
| Total | $0.57225 |

The results of milling operations for the year were as follows:

| | | |
|---|---|---|
| Ore milled | 1,058,784 tons, | 2.30% copper |
| Concentrates produced | 45,410 tons, | 38.09% copper |
| Copper in concentrates | 34,597,568 pounds | |
| Copper per ton ore | 32.68 pounds | |
| Mill extraction | 71.06% | |

The cost of refined copper in concentrates on board cars at Miami, based on net smelter returns, was 7.9 cents per pound.

The company has developed about 6,000,000 tons of mixed oxide and sulphide ore, for which it hopes to develop a combination concentration and leaching process.

The 24th annual report of the Wallaroo and Moonta Mining & Smelting Co., Ltd., South Australia, covers the operations during the year 1913. The report of the general manager, Mr. H. Lipson Hancock, states that the results of the flotation process at the concentrators has justified the expenditure made therefor, and is enabling the company to make a higher recovery of copper. The treatment of the slime tailing dumps at the Moonta mines, by leaching and precipitating, has been improved through a system of regular plowing which expedites oxidation of the copper minerals and yields a liquor richer in copper. Similar work at the Wallaroo mines has been discontinued in favor of flotation. One blast furnace in operation for 308½ days smelted 90,190 tons of charge. The output for the year was 7112 tons refined copper, 2161 ounces fine gold, and 1000 ounces silver 996 fine. The acid works produced 5602 tons sulphuric acid.

## The Iron and Steel Market

While the stagnation in the iron and steel market was not greatly accentuated in May, there being, indeed, very little margin left for such a change, the dissatisfaction of the trade with existing conditions was greatly increased, because it became high time for an improvement to set in. The market lost ground constantly throughout 1913, and towards the close of the year a period of inaction lasting several months was indicated. Somewhat to the surprise of the trade a rather substantial revival occurred in January, and the recuperative power thus shown gave the trade much encouragement, so that it expected, after perhaps a lull of a month or two, a prolonged and marked improvement, particularly as the advent of spring normally brings increased consumptive requirements. As week after week has passed with the market showing somewhat increased stagnation, instead of marked improvement, the trade has become much depressed.

The output of finished steel in May has not been more than about 55 per cent. capacity, against about 65 per cent. in April, the highest rate this year having been close to 75 per cent., early in March.

Steel bookings during May have probably averaged somewhat less than 50 per cent. of capacity, and were at approximately a stationary rate during the month.

As in April, the course of steel prices has been downward, though not markedly so. Prices were already so near the cost of production, taking cognizance of depreciation and fixed charges and the increase in cost due to light operation, that all declines have met with stubborn resistance.

Towards the close of May a change occurred in sentiment, the trade becoming rather hopeful that some slight improvement at least would occur before midsummer, on the theory that stocks were altogether depleted throughout the country, with actual ultimate consumption at a rate in excess of the current mill shipments. Hopes for good business in the second half of the year were augmented by the extremely favorable crop outlook, reinforced by evidences that the railroads were placing themselves in better position by the practice of severe economy.

Wage reductions, seriously discussed by independent mills in April as a probable necessity should conditions not improve within a short time, are still under consideration, but the positive attitude the United States Steel Corporation is known to have assumed against any wage reductions is likely to act as a deterrent influence, the independents fearing that they would be placed in an embarrassing position.

### Pig Iron

May saw a decided revival in interest in the pig iron market. Several steel interests purchased basic pig iron for third quarter, and in one or two instances for the entire half year, while there was a marked increase in sales of foundry iron in small lots. In some quarters the increased activity of pig iron has been held to presage a general improvement in the iron and steel industry, but it will do no harm to reflect upon the fact that last summer witnessed a decided improvement in the pig iron market without any improvement in the steel market. What occurred then was that pig iron buyers put off their purchases until many were forced into the market at the same time, and, while their purchases advanced prices slightly, the market began to weaken again as soon as the buying was over, and eventually reached a lower level than ever. About the beginning of May it was quietly announced that Lake Superior ores would be sold for 1914 delivery at the 1912 schedule, involving reductions from 1913 of 55 cents on non-Bessemer and 65 cents on Bessemer ores, the announced prices being: Old range Bessemer, $3.75; old range non-Bessemer, $3.05; Mesabi Bessemer, $3.50; Mesabi non-Bessemer, $2.85, on Lake Erie docks. It is since rumored that sales have been made at 15 to 20 cents under the announced prices, but irrespective of prices the sales have not been large, and the "opening" even though delayed has been quite different from openings in most previous years, when large tonnages were placed under contract in a few days. The decline in ore from 1913 to 1914 is held not to necessitate or permit any decline in pig iron, it being maintained that the pig iron market in its declines had already discounted the reduction in ore, which was fully expected even before the close of 1913. Connellsville coke has weakened somewhat, there being a few contracts made for delivery after July 1 at well under $2, the price to which the majority of operators have steadfastly adhered for months. The pig iron market stands quotable as follows: No. 2 foundry, f o.b. Birmingham, $10.50; delivered Philadelphia, $14.75 to $15; f.o.b. furnace, Buffalo, $13; delivered Cleveland, $14.25; f.o.b. furnace, Chicago, $14; at valley furnaces (90 cents higher delivered Pittsburgh), Bessemer, $14; basic, $13; No. 2 foundry and malleable, $13; forge, $12.50 to $12.75.

### Steel

The market for billets, sheet bars and rods was quiet throughout the month, there being no prompt requirements to be filled and very little interest in deliveries after July 1, to which date consumers seemed to be well covered. Market prices are largely nominal, as follows: Billets, $20; sheet bars, $21; rods, $26, at maker's mill, Pittsburgh or Youngstown.

### Finished Steel

Slight weakening occurred during the month in the majority of products. Prices named below are f.o.b Pittsburgh unless otherwise noted:

Rails, standard sections, 1.25c. for Bessemer and 1.34c. for open-hearth, f.o.b. mill, except Colorado.

Plates, tank quality, 1.12½c.

Steel bars, 1.12½c. base.

Shapes, 1.15c.

Iron bars, 1.30c., Pittsburgh; 1.22½c., Philadelphia; 1.10c., Chicago.

Wire nails, $1.55 to $1.60, base; plain wire, 1.35c. to 1.40c.

Sheets, blue annealed, 10 gage, 1.35c.; black, 28 gage, 1.85c.; galvanized, 28 gage, 2.80c.; painted corrugated, 28 gage, 2.05c.; galvanized corrugated, 28 gage, 2.85c.

Merchant steel pipe, ¾ to 3 in., 80 per cent. off list.

Steel boiler tubes, 3½ to 4½ in., 72 per cent. off list.

Standard railroad spikes, 1.40c., Pittsburgh, 1.50c., Chicago.

Structural rivets, 1.60c.; boiler rivets, 1.70c.

Cold rolled shafting, 66 per cent. off list.

## American Electrochemical Society

The twenty-sixth general meeting of the American Electrochemical Society will be held at Niagara Falls on Thursday, Friday and Saturday, Oct. 1, 2 and 3, 1914. A local committee has been formed with Mr. L. E. Saunders as chairman.

Mr. F. A. Lidbury, works manager of the Oldbury Electrochemical Company, of Niagara Falls, is the president of the society. Dr. Joseph W. Richards, Lehigh University, Bethlehem, Pa., is the secretary.

## BRITISH IRON AND STEEL INSTITUTE

The annual meeting of the Iron and Steel Institute was held in London on May 7th and 8th, 1914. Annual reports of officers were presented and the president-elect, Mr. Adolphe Greiner, was introduced into office. The Bessemer gold medal for 1914 was presented to Mr. Edward Riley. Following is the list of papers on the program:

The Forms in Which Sulphides May Exist in Steel Ingots. By J. O. Arnold and G. R. Bolsover.

Experiments on Allotropy of Iron (Behaviour of Ferro-Magnetic Mixtures; Dilatation of Pure Iron). By C. Benedicks.

Recent Developments of the Iron and Steel Industry in India. By A. Bose.

The Recrystallization of Deformed Iron. By C. Chappell.

The Hardening of Iron and Its Alloys. By C. A. Edwards and H. C. H. Carpenter.

Influence of Molybdenum Upon the Corrodibility of Steel. By J. N. Friend and C. W. Marshall.

Note on a Curious Case of Decarburization During the Hardening of Steel Dies. By H. C. Greenwood.

The Magnetic and Mechanical Properties of Manganese Steels. By Sir Robert A. Hadfield and B. Hopkinson.

Case-Hardening. By H. L. Heathcote.

Failures of Heavy Boiler Shell Plates. By S. A. Houghton.

Production of Steel Direct from the Ore. By E. Humbert and A. Hethey.

Theory of Hardening. By A. McCance.

The Colorimetric Estimation of Sulphur in Pig Iron and Steels by Paper Impregnated with a Solution of Arsenious Anhydride in Hydrochloric Acid.

The Development of Dry Cleaning in Blast-Furnace Gas Purification. By F. Muller.

A New Reagent for Etching Mild Steel. By W. Rosenhain and J. L. Haughton.

Talbot Process at Witkowitz. By F. Schuster.

# Is There a Complex-Ore Problem?

## A Symposium on the Economics and Metallurgy of Mixed Base-Metal Sulphide Ores, Showing Present Status and Future Prospects of This Branch of Ore Treatment

In our May issue we published the first batch of replies received from a number of prominent metallurgists to an inquiry submitted to them in form of the following six questions:

1. Is there a "complex-ore problem," and what, in your opinion, constitutes a "complex" ore?
2. Would such ores be amenable to present methods in the hands of skilled operators, or is there a need for new methods of treatment?
3. Do you believe there are many mines now idle which could produce a considerable tonnage of such ore if suitable methods of treatment were known?
4. What element or quality of such ores makes them refractory to present processes?
5. What methods or processes do you regard as probable solutions of the problem (mechanical, hydrometallurgical, electrometallurgical)?
6. To what extent would microscopical examination of such ores be of material assistance in suggesting proper methods of treatment?

The following replies, since received, will be found equally interesting:

**Stuart Croasdale.**—If we are to adhere to the usual definition of an ore, as a mineral or group of minerals which can be worked at a profit, many of the so-called complex-ore bodies do not exist. If we are to consider as complex-ore, what one engineer has aptly termed a "mineral aggregate," or a group of minerals which cannot be worked at a profit, individually or collectively, by existing methods or under existing conditions, but which have an assumed value based on the gross market value of the merchantable metals contained therein, then the field might be broadened even to the sands of the sea.

However, placing both ore and "mineral aggregate" containing from two to five of the more common merchantable metals under the term of complex-ore, I think the available quantity of this material is greatly overestimated. Improved methods of ore treatment may increase the number of producing mines to some extent, but my experience has been, in examining properties of this character, that the ore bodies frequently are too small to justify the erection and operation of a reduction plant, and too low-grade to ship crude to a custom plant, except in very favored districts. When the "ore in sight" will not pay, or more than pay, for the property itself and a suitable metallurgical plant, the problem becomes very simple. On the other hand, we all know there is a proportionate number of good properties containing large tonnages of complex ores, which are now standing idle or are operating at an unsatisfactory profit.

The only method now in use for the treatment of these ores is the mechanical concentration and separation of the minerals into marketable products for lead and zinc smelteries. This is necessarily done at the mines to avoid transportation of large quantities of gangue or worthless material. Losses occur at every turn. A typical recovery by this method in a Colorado mill, equipped with every type of device for concentration and preparation of commercial products, is as follows, based on the assays of crude ore and tailings: Gold, including free gold sold as bullion, 75.9 per cent; silver, 50.6 per cent; lead, 86.7 per cent; zinc, 58.6 per cent; copper, 55.0 per cent. Higher recoveries have to be sacrificed in order to maintain the products at a marketable grade. To the above losses must be added smelting charges, deductions, penalties, and metals in each product not paid for, the amount of which is appalling.

As an illustration of these losses, a recently published statement relating to a Montana property is significant. The ore can scarcely be called complex, for it was milled for zinc alone. Concentration and flotation are said to recover over 90 per cent of the minerals in the crude ore.

The zinc product contained 50 per cent zinc, 2.4 per cent lead, 0.5 per cent copper, 26.3 oz. silver and 0.05 oz. gold per ton, and cost $4.56 per ton to produce. This concentrate had a market value at the mill of $23.79 per ton. The gross value of the merchantable metals in this product, based on current quotations, was $80 per ton. Therefore, $56.21 per ton disappeared between the mill and consumer. This paid legitimate freight and smelting charges, of course, but mostly it represented metals not paid for which lie in the "residue" dumps at the zinc smelteries. How much greater are similar losses from complex ores?

Surely the present method of treatment is not all that can be desired, and it is scarcely conceivable that the cost of treatment in a more direct and refined metallurgical process, whatever it may be, will exceed the cost, plus the losses sustained by mechanical concentration and smelting.

The refractory character of complex ores is usually due to the chemical combination or physical arrangement of the minerals, and a microscopical examination of such ores will undoubtedly aid in an intelligent solution of the problem of their treatment.

No method of treatment can be considered the best for all complex ores. Each ore is a problem in itself. In some ores the minerals are coarsely crystalline and easily separated into comparatively clean high-grade products. Such ores, even, with the attendant losses, may be best adapted to mechanical concentration.

Other ores, when examined under the microscope, will reveal the minerals intimately associated in very small crystals, or perhaps in non-crystalline form, which, if separated, will involve so much loss in sliming and subsequent smelting that any form of mechanical separation would be condemned as impracticable if other processes were available.

In still other ores chemical combination exists in the form of double sulphides of the metals. The rational treatment of such ores certainly is not mechanical beyond the removal of a portion of the gangue, for no product can be made that will not involve a considerable loss in the form of a metal not paid for.

As stated before, only one method of treatment now exists—that of mechanical concentration and separation. The consulting engineer cannot recommend the installation of untried processes, no matter what his opinions and experimental results may be. His clients are like the gentleman from Ohio in the selection of horseflesh. They do not want a process that "has been" or "is to be." They want an "izzer." Therefore, the engineer wears the ore to a frazzle sending it through the interminable mechanical grooming and gets the best results he can with from 20 per cent to 30 per cent combined loss in tailings; his lead product containing 10 per cent unrecoverable zinc, his zinc product containing 10 per cent unrecoverable lead and more or less unrecoverable silver—all of which is, of course, unpaid for, if not penalized. If he can figure a profit when he is through, the system is installed; if not, the property stands idle awaiting a better method of treatment.

New processes cannot be put into operation by the discoverers nor by stock companies. They must be matured by companies that are working complex ores at a profit under existing methods and wish to improve their condition. This can be readily done by appropriations set aside from the earnings, which would virtually come from the properties themselves and not from the shareholders. In case of failure the loss of such an investment will not be felt, and in event of success the science of metallurgy, as well as the mine, will be amply rewarded.

If managing engineers in charge of properties of this kind would devote more time and energy to the development of new processes along lines best adapted to their ores, whether that process be hydrometallurgical, electrometallurgical or pyrometallurgical, I believe we would get out of the mechanical rut and make considerable advance in the treatment of complex ores.

There is a decided tendency in this direction at the present time among the large copper companies, particularly in connection with the treatment of low-grade porphyry ores, where the concentration and smelting losses are between 35 and 40 per cent, and also where large quantities of oxidized ores exist for which there has been no method of commercial treatment available. It is a pleasure to hear of the extension of this work to lead properties, and it is to be hoped that the complex ore properties will soon fall in line.

Much could be gained by combined and organized research among these respective types of properties, whereby a great deal of duplication of work and discouragement could be avoided. I know of a number of cases where work of this kind has been duplicated independently by engineers, and abandoned at the same point; whereas, if the second engineer could have profited by the experience of the first, both would have gained in coin and reputation, and a positive advance would have been made in metallurgy. If it is impossible, as some have said, to overcome professional jealousy in organized research of this kind, why not permit the Bureau of Mines to co-operate with and receive financial assistance from mining companies for such work in proportion to the benefits obtained, and thereby develop an "all star," impartial, national research staff.

Denver, Colo

**H. M. Parks.**—I have noted, in being around different mining camps, the general opinion which your questions suggest. Although the miner and prospector often speaks of the question as "the complex-ore problem," it seems to me that it might more properly be designated a phase of a "complex-ore problem." In other words the mixture of base-metal sulphides is an ore amenable to treatment by existing processes at a higher cost and treatment loss than one carrying only one valuable metal. Accordingly such a mixture, to be an ore in the present accepted meaning of the term, must have a total value considerably in excess of that needed when the value is all represented in one metal.

There certainly are millions of tons of rock containing metal values of such grade that they cannot now be treated at a profit, which may sometimes become profitable through the invention and improvement of processes, improvement of transportation facilities, etc. Many of our "complex ores" coming into this category have total metal values greater than other ores in the same locality which are being treated profitably for only one metal. That ore A worth $5 is being treated profitably, and ore B at the same mine worth $8 cannot be treated at profit, causes much comment; but when we consider that the valuable metal in A has but to be separated from the gangue, while several metals in B must also be separated from each other, we see that it is about as imperative to demand a new process to handle ore A as ore B.

We do need and probably always shall need improvement in our processes for treating ores, whether simple or complex; but it is probably true that the field is larger for treating the complex ores because the problem is more variable. The current impression that the "complex ore" is a present day metallurgical bug-a-boo is quite erroneous.

Corvallis, Ore.

**Robert H. Richards.**—Answering your questions briefly, will say that:

1.—A complex ore is one that is fine-grained, containing minerals that are difficult to separate, but which would have greatly increased value if separated.

2.—Some of these ores would yield to present processes skilfully applied, but others need new processes for their profitable treatment.

3.—It is reported that there are many mines now idle which could produce a considerable tonnage of ore if suitable treatment processes were known, but I am not in a position to know.

4.—Zinc seems to be the worst stumbling block in the metallurgy of complex ores.

5.—In my opinion all three of the types of processes mentioned—mechanical, hydrometallurgical, electrometallurgical—either separately or collectively, will be used in solving the problem.

6.—The use of the microscope would aid in determining the minerals present.

Boston, Mass.

**W. McA. Johnson.**—Metallurgically speaking an ore may be defined as mineralized material containing metal in sufficient amount and purity as to permit its profitable extraction. The terms "simple" and "complex" are relative and can best be illustrated by examples of each class. For instance, a simple ore is one that contains one metal constituent only, or so great a proportion of one metal as to permit of its extraction by a simple furnace treatment, the subordinate metal or metals, if present, not interfering with the extraction of the chief metal. This is exemplified by the ordinary sulphide or oxide ores of lead, of copper, or of zinc. When, however, the ore contains two or more metallic minerals in such a physical form as not to admit of separation by mechanical methods, and if the contained metals could not be easily extracted by present furnace methods, such an ore would be called a "complex ore." This might be exemplified by an intimate mixture of galena, blende and chalcopyrite or chalcocite—say 30 per cent zinc, 10 per cent lead, with or without a small percentage of copper; or copper 3 per cent and zinc 30 per cent. In cases of this kind the percentage of zinc present is too great to admit of smelting economically in the lead furnace, and the percentage of lead too great to permit of the profitable extraction of zinc in the ordinary retort furnace.

The question of the proper method of treating complex ores, such as those just quoted, constitutes the problem, and it is one that has remained unsolved in many instances.

Your second question, as to the amenability of complex ores to present day processes, provided skilled operators conducted the treatment, practically answers itself in the fact that there still remains the problem. Metallurgy is always progressing, and that which was good practice a few years ago is now considered bad practice; losses in slags and tailings permitted in the state of the art ten years ago would not now be allowed. For example, the porphyry copper ores of Utah could not have been treated profitably by processes of a decade ago, yet today they yield handsome returns—and even now the present practice is far from perfect, in that the tailings from the mechanical concentrators are stored up for future extraction by methods not yet devised or perfected. Hence an ore may be refractory today and easy to treat by improved or new processes tomorrow. The application of the laws of physical chemistry and commercial science, cemented by common sense and due diligence, will solve many a problem which heretofore has been too complex for a profitable solution. Eternal experimenting is the price of progress.

I decidedly do think that there is a need for new methods of treatment of the so-called complex zinciferous lead or copper ores, and I have devoted ten years of careful study and research to develop my present process, which I believe promises to settle many perplexing questions of metallurgical treatment.

As to possible idle mines which could produce a considerable tonnage of complex ores if suitable methods of treatment were available, I will say that I recently conducted a two-months' advertising campaign which had for its object the gaining of information as to the need of a process which would extract practically all of the metal content of zinciferous lead or copper (or both) ores, and my files are filled with letters from all parts of the country. In most of these letters the ore mentioned is not now being marketed, although the total combined metal values show a good working margin. Whether these deposits represent the "millions of tons" referred to in your letter I have not as yet computed, but they appear to be quite extensive and in need of some process which will render their treatment commercially profitable.

The Johnson electric furnace process, as developed to its present state of efficiency, can extract from ores practically all of the contained zinc, lead, copper and precious metals, in one smelting operation, thus avoiding the wasteful process of concentration in which there is an unavoidable and large loss of mineral in the tailings, and eliminating the subsequent heavy penalty charge for treatment by the smelter of the large percentage of zinc usually present. Moreover if one considers that during the past year the value of the zinc which was thrown away in the slags of American smelting furnaces aggregated $30,000,000 (equivalent to two-thirds the output of zinc in the United States for that year), the great importance of a process which will save the zinc in these complex ores is manifest. This question is answered in the strong affirmative by the contents of the many letters received.

In reply to question 4, I should say that the cause of the refractoriness of these complex ores is chiefly the presence of a high percentage of zinc, the ores being so constituted physically as not to be amenable to separation of the component minerals by mechanical treatment.

I consider that the Johnson electric furnace process will solve most of the problems now under consideration; and while there may be future progress in the mechanical and hydrometallurgical fields, their application for the treatment of zinc ores does not seem to me to be promising of satisfactory results.

Your final question as to whether or not a microscopical examination of complex ores would be of material assistance in suggesting proper methods of treatment, is one of interest; but the application would be of value chiefly as an aid to determine the proper methods of mechanical concentration. If the ore were rich enough it could be smelted direct in the electric furnace, but a case might arise in which it would be desirable to concentrate the ore (even though some of the mineral content be lost) prior to smelting. As a general rule the details of the electric furnace treatment have to be determined for each individual ore, if wholly satisfactory results are to be attained.

Hartford, Conn.

**Francis A. Thomson.**—1.—There is, I think, in a limited sense a "complex-ore problem," but the problem is less serious and not as general as is commonly supposed.

By a "complex ore" I mean an ore containing sulphides of copper, zinc and lead in sufficient quantities to justify the recovery of all three metals, with of course the usual accompaniment of gold and silver.

2.—Such ores are in part amenable to treatment by present processes when properly conducted. This is more true of the recovery of the copper and lead than of the zinc. There is a moderate demand for a process which will permit more complete recovery of all three metals than is now possible.

3.—To my knowledge there are very few mines lying idle because of the complexity of their ores. I have had occasion to examine many mines, which were claimed to be idle from this cause, but have never yet found the claim to be true. Quantity or value of ore was lacking in every case.

It is my experience that this claim is often the means by which ignorant or deceitful persons impose "fake processes" and fraudulent promotions upon the public.

4.—There are mainly three causes of the refractoriness of complex ores:

a. The intimate intermixture of the sulphides mentioned.
b. The lack of difference in specific gravity between chalcopyrite and sphalerite.
c. The volatility and ready oxidability of zinc.

5.—For (a) and (b) in the preceding classification, magnetic or electrostatic separation seems to promise best. Flotation also may come to have an important place.

For (c) electric smelting would seem to have possibilities in view of the ease of control of furnace atmosphere and temperature. Of course, proposals for a sulphatizing roast of the Ziervogel type, with subsequent leaching with water, or an oxidizing roast with a sulphuric acid leach, the acid being made from the gases of the roasting operation, are always with us and may some day displace igneous concentration, but this is doubtful.

In general the progress of the future will be like that of the past—slow improvements step by step rather than sudden changes of a revolutionary character.

6.—Microscopic examination of any ore as a preliminary to devising a treatment scheme is exceedingly valuable, and all of my students are being trained to appreciate its value and to make use of the microscope daily for problems of this kind.

Pullman, Wash.

**Lewis B. Skinner.**—I would say, in the first place, that what is generally termed a "complex ore" is a mixture of the various metal sulphides such as zinc, lead and iron. Such ores may or may not contain gold and silver, but usually do. There is usually some gangue with these sulphides, which is commonly of a silicious nature, but may be lime, dolomite or barytes.

In answer to the second part of the question, would say that there certainly is a complex-ore problem. There is also a gold-ore problem, a lead-smelting-ore problem and, in fact, problems in the handling of all ores. Every one who is trying to work as efficiently as possible is trying to cut down the manufacturing costs of all of the metals. Since complex ores usually contain the metal zinc as the most valuable constituent, I refer more particularly to zinc itself when referring to complex ores.

We hear a great deal about the terrible loss that obtains in reducing metallic zinc. This is no worse than that obtaining in the production of other metals, i.e., putting them into merchantable shape. Were we without any processes at all for the manufacture of zinc or spelter, we would then have a real problem; but we are not without methods, which, while not as efficient as any one desires, are still able to compete against a given market and turn out a sufficient supply of metal.

2.—Usually the first step in the production of any of the metals is ore-dressing. The ores as mined are of too low a grade to be handled directly in any smelting operation. It is not a fact that poor methods make the losses high, but that the handling of ore-dressing methods is deplorable. There are only a few plants practicing ore-dressing that do so with the idea of getting every pound of available material. It is usually only a question of whether the mill, taking its own mine ore, is paying a profit. If it does not, the mine is blamed for it. If it does, all are satisfied. The poor quality of mill operation is no doubt responsible for the notion that there is a complex-ore problem. To offset this many experimenters have undertaken to get up a new mode of procedure which, in itself, usually proves to be much more cumbersome, if not apparently more wasteful, than the ones that are commonly used and yet condemned owing to lack of ability in the operator.

A great improvement could be had if the present methods of ore-dressing were handled in a businesslike and satisfactory manner; but it would be very foolish to say that some new procedure would not prove, in some cases, more desirable than the known methods. You, Mr. Editor, and I know, that there is too much of a general tendency on the part of persons advocating new schemes to want to throw all of the good, known, tried processes out of commission and immediately start off on new lines.

It is possibly several decades since the use of platinum sponge as a catalyzer for the union of sulphur dioxide and oxygen was first announced. It has taken all of these decades with much expensive and strenuous investigative work, coupled with high engineering ability, to evolve schemes which are now known as "contact processes" for the manufacture of sulphuric acid. Even at that, the contact processes will compete only under given commercial conditions. When, therefore, a person drops into the complex-ore field and immediately announces a new process, one is inclined to be skeptical as to the engineering of it, at least, although the fundamental principles involved may seem to be sound. It has been repeatedly proven that a simple procedure, coupled with high operative efficiency, usually beats any intricate procedure having too great a demand for high class labor and care in watching the various steps. The answer in any case is a matter of dollars and cents. If the old procedures, which may seem to be somewhat wasteful, cost little for operation and something more for actual loss of metal at its valuation at the point of treatment, and these costs prove to be less than those of some more elaborate procedure having possibilities for higher recoveries, it is merely a question of the survival of the fittest, which, in this case, will be the scheme first outlined. With the possible exception of electric zinc smelting as now being tried out, it has been proven under any conditions that I know of that complex ores should be treated by simple ore-dressing, followed by the old procedures, as against any new chemical or other sort of a scheme outlined to date.

3.—I do not think there are many mines now idle for lack of suitable treatment processes. I know of several "scouts" of the large companies who complain that they are unable to locate such large tonnages of ore as several enthusiastic people are inclined to believe exist.

4.—There are two conditions which might obtain: one is where the various constituents are so finely disseminated that extremely fine grinding is necessary; and the other where the mineral particles are composed of the metals upon which separation is desired. In other words, chemical combination or fine mechanical combination makes these ores refractory to present processes.

5.—Mechanical methods, coupled with the various smelting processes for the different metals, is the general procedure now adopted. The hydrometallurgical schemes do not seem to offer much for the reason that they necessitate the handling of salts of high heats of formation in large volumes of solution, calling for a high investment cost and demanding expensive chemicals. I think the electrometallurgical presents the only line worth while, in that either the electrothermic or electrolytic methods may be undertaken. With regard to the latter, one must be sure of the commercial aspect and first go thoroughly into the power situation. With the prospect before us of cheaper power from hydroelectric stations, some electrometallurgical procedure should be evolved which will ultimately yield cheaper metal. .

In passing, since there are fads in metallurgical lines as well as in others, I might note that we are going through a stage when the whole fraternity is on the qui vive trying to make every ore amenable to treatment by some flotation process. In the case of one-mineral separation in the United States this process has proven an aid; but it is of no benefit in the case of ores of zinc, which are truly complex, although being advocated for such. I do not know of any complex ore in Colorado, for instance, that could possibly show any advantage under this treatment.

6.—Almost every one examines ore with a magnifying glass or even goes so far as to use a microscope. We use both and are guided thereby. Almost every one in the ore-dressing business or ore-handling business uses on or the other and gains a great deal of information. When it is indicated by magnifying that extremely fine crushing is a necessity, mechanical separation then becomes out of the question, unless under peculiar circumstances.

Denver, Colo.

**Arthur J. Hoskin.**—1.—Yes, such a problem does not exist. To me a complex ore is one that contains or is made up of two or more base-metal minerals—not necessarily sulphides—each of which could be marketed if suitably separated or otherwise prepared to fit commercial demands. In some instances of ores containing more than two minerals, it may be sufficient to make but two products. Thus, if an ore contain galena, sphalerite and chalcocite, the three metals thus represented could each be realized upon in the market if the sphalerite were removed cleanly from the other two minerals. I once considered an ore composed principally of sphalerite and barite complex. I had such an ore and was assured of a good market among paint manufacturers for clean oxide of zinc and sulphate of barium. It was before the days of electrostatic, flotation and magnetic separations. The minerals of the ore could not be effectively separated by the then existing table methods, either wet or dry, as their specific gravities were nearly the same. To me it was complex, but both minerals were not sulphides. I would certainly call a mixture of molybdenite and biotite complex, since I understand that these minerals do not separate well under any of the present processes, and yet there is a market for each mineral when clean.

2.—Certain combinations of minerals that are now classed as complex ores are undoubtedly amenable to present methods in the hands of skilled operators; but there are other ores, the satisfactory dressing or treatment of which has not been discovered.

3.—I know of a few mines lying idle from this last cause, and I presume there are many.

4.—Among the physical properties that have thus far proved obstacles in the thorough separation of such minerals I would mention similarity in specific gravity; shapes of crystals; similar action in flotation; equivalent electrical properties; similar magnetic properties; equal solvency in chemicals; similar action under heat.

5.—It would seem that there is a field for all three general sorts of treatment.

6.—The microscope would reveal such peculiarities of the physical structures of the associated minerals as would be useful in deciding upon the degree of fineness to which ore should be ground, and it might also determine the most desirable method of pulverization.

Denver, Colo.

**George H. Scibird.**—I define a complex ore as a difficult ore, or one which is refractory to profitable treatment by ordinary prevailing processes; and with this definition in mind, the statement that there has existed a complex-ore problem, locally, becomes true. To convey some idea of the nature of one such ore, the following analysis is given:

| | |
|---|---|
| Gold | 0.11 oz. per ton |
| Silver | 11.00 " " " |
| Insoluble | 85.00 per cent. |
| Iron | 2.75 " " |
| Manganese | 2.25 " " |
| Lime | 3.00 " " |
| Copper | 0.60 " " |
| Lead | 1.00 " " |
| Zinc | 1.25 " " |

The character of this ore is such that concentration by any practicable method was unsuccessful, while only fair results were ever obtained by combination of various processes.

In this particular case, it is improbable that skill on the part of the operator would have helped the situation, because the metals existed in the ore in such a condition that their recovery apparently was impossible within commercial bounds. In this respect the ore was not amenable to treatment by existing, proved processes. Thus it became evident that either a new process must be found, or some old process, with modern methods applied, be revived. In fact, this has been done. In developing the process an effort was made to overcome the weaknesses of the old chloridizing-roasting process, such as loss by volatilization, high cost and low extraction, and by improved chemistry in the use of solvents. The application of modern, highly specialized machinery will also prove of great benefit in the new plan of treatment. Thus, the Christensen process, strictly speaking, is not new when considered as a revival of the chloridizing process, but it embodies new ideas in a very large measure, and is so improved that it bids fair to take a most important position in the treatment of what have been complex ores in the sense of my definition.

While there are not, locally at least, many mines that are actually idle for want of such a process, there are many which are seriously hampered by a vast tonnage of non-smelting-grade ore which may well become a valuable asset with the adoption of this treatment. When, however, the country at large is considered, there are several properties, now idle, which can readily be remembered, that could be made profitable by the new process, and there are more which might operate to better advantage with this method of treatment than under their present process.

There are several features which have proved detrimental in connection with the ore. First may be mentioned the value. This figure is such that smelting is out of the question. Secondly, the base metals occurring as carbonates and chlorides, with the gold in an extremely fine state of division, makes concentration unsatisfactory; while cyanidation either alone or in combination with concentration is only fairly successful. Leaching with various solvents, roasting, and in fact the whole category of usual procedures, is not promising. The new process, however, promises to save the situation.

Thus, at least locally, and to a considerable extent, generally, the modernized chloridizing-roasting and leaching process will prove of immense value in solving the difficulty, although where the gangue is limestone this process is not perfect. It will, however, make available the value in a tremendous tonnage of ore which is at present worthless.

Salt Lake City, Utah.

**R. D. George.**—My various trips to the San Juan and other districts in Colorado, particularly in Boulder county, have led me to the opinion that there are large quantities of low-grade ore in the State which cannot be profitably treated by the present methods. A great deal of money is spent on processes, plants, and mills of various kinds without scientific investigation of the material to be treated, and the adaptation of the methods to local conditions.

1.—I have heard the term "complex ore" applied in the following cases:

a. Where the metals contained in the ore are in minerals of like specific gravity and therefore difficult to concentrate. An example of the kind would be zinc sulphide and pyrite.

b. Where the metallic contents are so disseminated through the gangue material as to make concentration difficult, if not impossible. This is the case with some of the tungsten ores of the eastern part of the Nederland area where cherty quartz and ferberite are so intimately mixed in such small grains that any type of crushing leaves the ferberite grains with sufficient gangue attached to make a low grade concentrate, and the quartz grains carry away sufficient attached ferberite to make the percentage of saving low.

c. Where there is considerable variation from place to place in the quality of the metallic mineral contained, as in the San Juan region where the silver, for example, may occur in any one of ten different forms, such as native silver, argentite, cerargyrite, stephanite, pyrargyrite, freibergite, proustite, silver-bearing tetrahedrite, silver-bearing tennantite, and argentiferous galena, along with pyrite, chalcopyrite, sphalerite, anglesite, hinsdalite, and a dozen others, and gangue minerals such as rhodochrosite, rhodonite, jasperoid, etc.

d. Ore deposits in which no definite line can be drawn between the oxidized and the unoxidized portions and in which sulphides, carbonates, oxides, and tellurides are intimately mixed.

e. To deposits in which many metallic bases of value are mingled in the same ore, as in some places in the San Juan region where operators are puzzled to know whether their values are chiefly in the form of lead, silver, gold, copper (tungsten), or zinc, or all of these together.

2.—I believe that modifications of present processes to meet local needs could be made by experienced and skillful operators in such a way as to overcome many of the difficulties. Again cooperation between treatment plants would make it possible for specialization in mills to meet the demands of certain types of ores. In the past, the custom in building mills has been to generalize in such a way as to meet every possible type of ore. This seems to me to be contrary to scientific principles and economic considerations.

3.—I am more familiar with conditions in Boulder county than with those in most other parts of the State, and I am convinced that, with suitable concentration plants and other treatment processes, idle mines of Boulder county could furnish a very large tonnage. This is also true of parts of Gilpin and Clear Creek counties, particularly the Georgetown and Silver Plume areas.

4.—This question has been answered rather completely under No. 1.

5.—I believe that the varieties of ore and the purposes for which they are treated are such as to demand mechanical improvements in concentration, modifications of the hydrometallurgical processes, and to warrant more thorough and careful electrometallurgical experiments.

6.—I have long advocated the careful microscopic examination of the so-called complex ores as an aid to the mill man and the metallurgist. I talked this matter over with Dr. Holmes of the United States Bureau of Mines some years ago, and urged the desirability of attacking the problem from this standpoint. I also outlined a method of attack, and the data to be sought in such methods. I believe that some work has been done since by the Bureau of Mines, though I do not know the extent of the work or its results.

Boulder, Colo.

**S. E. Bretherton.**—Yes, there is a complex-ore problem. One type of complex ore is a sulphide containing both zinc and copper, zinc and lead, or zinc, copper and lead, with or without silver and gold. I might name another complex ore, low-grade, silicious, oxidized copper ore. The absence of sulphur and high percentage of silica prohibits such ore being smelted for the production of copper matte, if such ore is located in districts where iron sulphides are not plentiful. Concentration of such oxidized copper ore is not practical, and the presence of alumina, iron and often some lime makes leaching methods by the use of acid too expensive, even if cheap metallic iron should be available for the precipitation of the copper after it is obtained in solution. The leaching of either copper or zinc ores when oxidized, often called carbonates, is not generally suitable for the ammonia carbon-dioxid process, as such oxidized ores are usually mixed with considerable quantities of silicates of copper or zinc, which prevents a high extraction by this last named process. For this reason I am more particularly interested in the treatment of sulphide ores, from which, after an oxidizing roast, the zinc can be recovered by leaching with ammonia and carbon-dioxid, and the other valuable metals recovered by the usual methods of smelting.

2.—When the ore is a sulphide and of suitable crystalline structure, zinc and lead can generally be separated by some of the ordinary methods of concentration, and sometimes zinc and copper can also be separated, but usually with excessive loss of gold and silver when the ore is rich in precious metals; but in a great many cases the structure of the ore will not permit of this mechanical separation. I believe there is a need for new treatment processes.

3.—Yes, if zinc could be added to the value of the ore in addition to the other metals, instead of being deducted by being penalized when the other metals are sold to the smelters as at present.

4.—Zinc is difficult to separate from copper by concentration. If the ore is smelted direct, the cost to recover the copper is increased by the presence of zinc, and the presence of zinc is much more objectionable when smelting an ore for the recovery of lead. (See answer to Question No. 1.)

5.—The processes most suitable would depend very much on the location of the mine where the ore is to be treated, as well as the analysis and structure of the ore. In some cases for sulphide ores, all three of the processes named may be required. Electric smelting with very cheap water power may come to the assistance of the retort or fire process, but even then considerable fuel is needed as a reducing agent with the roasted zinc ore, and a very expensive plant installation. For this reason it is reasonable to expect more development for the treatment of complex sulphide ores along the lines of concentration and leaching, and leaching direct. The complex zinc and copper sulphide ores of California are different in their structure to ores of the same analysis in Colorado, Utah and Arizona, and no known method of mechanical concentration is suitable for the ores of Shasta Co., Cal. Containing, as they do, considerable alumina and lime, any acid process does not seem suitable. For this reason the writer has developed the ammonia carbon-dioxid leaching process, which, so far, seems the only suitable process, requiring no fuel excepting oil which is the cheapest fuel in California.

6.—I would consider microscopical examination of any complex sulphide ore of material assistance in suggesting proper methods of treatment, as no doubt by experience the metallurgical engineer could decide in a short time whether mechanical concentration was suitable for the ore to be treated or not. We find that a powerful magnifying glass is a great assistance to us to quickly decide when the ore is properly roasted, and a more convenient and quicker means for the man in charge of the roaster than is the ordinary laboratory test.

San Francisco, Cal.

**William G. Haldane.**—1.—I think there is a "complex ore problem," although the term is used rather indiscriminately. I apply the name "complex ore" to such as exists in the San Juan region of this state, finely disseminated and intimate mechanical mixtures of the sulphides of copper, iron, lead, and zinc, and others of a similar nature.

2.—I believe that present processes in combination in the hands of skilled operators would accomplish much towards the solution of these problems, due to improvements and developments in the processes themselves, resulting from experimentation and use by such operators.

3.—There is not "millions of tons" of such ore, but an attractive field would be opened up if new processes were developed.

4.—The difficulties encountered in processes at present are largely mechanical, and result also from the

See "Preparation of ore containing zinc for the recovery of other metals, such as silver, gold, copper and lead, by the elimination and subsequent recovery of the zinc as a chemically pure zinc product," page 1141 in the August, 1913, *Bulletin of the American Institute of Mining Engineers* and F. L. Wilson's article on the same subject in the *Mining & Scientific Press* of March 14th last, page 453 attempt to use the same medicine for a number of widely different ills.

5 and 6. Am greatly in favor of combination methods. I think the tendency has been to apply to an ore containing a number of minerals, each with its own special characteristics, a process involving only one principle, as, for example, specific gravity. To illustrate further, an ore may contain, let us say, minerals 1, 2, 3 and 4, with 1 and 2 of high sp. gr. and 3 and 4 of low sp. gr. In this case a preliminary concentration and separation may be effected with tables. Minerals 1 and 2 may be widely different magnetically, or may be readily separated with electrostatic machines, and so on.

I thoroughly believe a microscopic examination would be of very great assistance as a preliminary step in the examination of these complex ores. It reveals properties and information at first hand that should be invaluable to an investigator. The microscope should be one of the first pieces of apparatus resorted to by every technical man in the investigation of the characteristics and physical features of an ore.

I am firmly of the opinion that our problem is a metallurgical one, but I believe closer attention to details and manipulation of our present processes will result in higher efficiencies and greater economies.

Golden, Colo.

**Warren F. Bleecker.**—1.—The term "complex ore' is an unfortunate one, because it does not mean anything specifically, but may be applied to any ore containing two or more valuable metals. In certain Colorado mining districts when one speaks of a complex ore he refers especially to base-metal sulphides containing zinc. In this sense the term is more or less reflective, since the method of treatment is the thing which is really complex. Unless one had the authority to limit the meaning of this term, he certainly could not embrace all of the meanings in a definition of unlimited length. For example, the mineralogist might place three vanadium minerals in the following order of complexity: roscoelite, carnotite, patronite. The technologist would certainly reverse the order. And I have reason to think that the analytical chemist would establish still another order of complexity for these three common vanadium-bearing minerals.

It is apparent, however, that the question refers to the base-metal sulphides. Those of the base-metal sulphides may be called complex which cannot be treated by standard mechanical devices; or in which no one valuable metal is in sufficient quantity to warrant profitable treatment; or in which there is a small quantity of zinc or a larger quantity of zinc which is chemically combined with the other values. It is obvious that if there were some cheap chemical which could be applied to cause the metals to be quickly and cheaply separated, the term complex would cease to be applied.

2.—Each ore presents a separate problem, be it a complex ore or a placer dirt, and the only method of getting at the truth will be the examination and report made by a reliable laboratory; or, still better, to send several carloads to a mill operating on a similar ore. If the mine is not exhausted by the loss of this quantity of ore, and the milling process is even moderately successful, the proposition would be very hopeful.

3.—I do not believe that there is a large quantity of good ore now developed and awaiting suitable methods of treatment. At the same time the present methods of ore-treatment are deficient, and development is held back accordingly. As known methods are improved and new ones devised, there will still be ores which are just on the line, and which will make further demands on the technologist.

4.—The quality of complex ores which contributes chiefly to their refractoriness to present processes is the distribution of values among several elements. Each element requires different methods of procedure in its extraction and subsequent recovery, and often it will cost more to recover an element than it is worth. For example, zinc is very troublesome, especially when chemically combined with iron. If the gold and silver also are with the iron, considerable difficulty will be experienced in getting any of these products out in a marketable form.

Another quality, which is a negative one, is a distinct lack of values in the ore to begin with. An ore is not necessarily worth treating because the total values foot up to ten or twenty dollars per ton. The aluminium from a clay carrying twenty per cent alumina would have a market value of fifty dollars, yet some difficulty would be encountered in deriving a profit from the treatment of such an ore. A true roscoelite carrying five per cent vanadium pentoxide might be said to have a value of $120 per ton, on the basis of a finished ferrovanadium, yet it would cost more than this to extract all of the vanadium and produce a marketable product from this class of ore.

5.—The problem is so indefinite, if indeed any problem exists, that it cannot be predicted which method of treatment will finally solve it. A shrewd guesser might do well to say electrometallurgical, because when taken in its broadest sense this term includes the other two.

6.—A microscopical examination would reveal the extent of mineralization, the size of crystals, and the general relation of the component parts of the ore. It is of great value to know what elements of the ore carry the values, and what its general physical conditions are.

I am of the opinion that complex ores which occur in sufficient quantities have a reasonably high metallic content, and show a fair paper profit after deducting standard costs and charges with a recovery of 50 or 60 per cent, will not have to wait long for a suitable method of treatment.

Canonsburg, Pa.

**S. A. Ionides.**—1.—The best answer I can give to the question "Is there a complex-ore problem?" is to quote from a letter recently received regarding an ore assaying about 5 oz. silver per ton, 14.5 per cent lead, 13 per cent zinc and 0.25 per cent copper.

> "I note our recent shipments of ore are running exceedingly high in zinc, frequently reaching 17 per cent. The lead content remains normal, but we are having the life penalized out of us because of the increase in zinc."

As long as a valuable metal is a source of penalty, instead of being an asset, there can be no doubt about the existence of a complex-ore problem.

Another phase of the problem is the loss in slime-tailing. Two such problems have recently reached me. In one case the slime tailing assayed 4 per cent lead, 2 per cent zinc and 2 oz. silver per ton. It constituted 20 per cent of the original feed to a concentrating mill which is regarded as doing excellent work.

Another slime tailing from a mill where the work is not so high class contained 17 per cent lead and 11 per cent zinc. Undoubtedly a lower tailing could be obtained from the latter mill by straight concentration, followed perhaps by flotation, but even so, the product would have a low economic value.

A complex ore may be defined as ore containing two or more base metals. In its simplest form such an ore need not give trouble. For example, a copper-lead ore containing precious metals is easily treated. A more limited meaning frequently is implied by the term "complex."

It involves the presence of zinc in the ore; and no instance is known to me where high recoveries of all metals are made from an ore containing lead and zinc, copper and zinc, or all three.

2.—Such ores as the one just mentioned have not proved amenable to treatment by present processes, in the sense that extractions exceeding 90 per cent of all metals can be made. It might almost be safe to say that this standard is never reached, for even if concentration was efficient, the smelting losses would reduce the total recovery below that figure. That there is a need for new treatment processes is evidenced by the fact that some of the large companies handling comparatively simple ore, are now engaged in elaborate experiments on new methods, particular reference being made to the copper leaching plant at Anaconda.

3.—From the number of inquiries received for methods of treating complex ores, there can be little doubt that a number of large mines require improved metallurgical processes. If the low-grade (10 per cent to 20 per cent) zinc carbonate ores of Leadville are admitted into the complex class, an estimate of "millions of tons" would be safe.

4.—The element that contributes most to the refractoriness of ores is zinc, and the quality or characteristic is friability.

A good commercial product can be made from ores containing copper or lead with precious metals; but inasmuch as a recovery of over 80 per cent is rarely made in practice, it may almost be said that these ores are refractory. The loss, in most cases, is due to slime; and the slime product from a lead or copper ore certainly is refractory.

The problem of concentration of coarse grades has practically been solved, and there is not much opportunity left for increasing the saving or reducing the cost.

Even so, there is room for improvement; for the miner still has to stand smelting and refining as well as concentrating losses.

The presence of zinc in an ore gives trouble all the way down the line, and if recovered with the lead it becomes a liability and not an asset. This point is accentuated as attention is now being directed largely to the solution of this particular problem.

5.—A solution of the problem along purely mechanical lines seems doubtful. Slime that will pass 150-mesh screen is invariably made in grinding, and the amount thus made frequently amounts to 20 per cent of the mill feed. The metal contents of this slime—gold, silver, copper, lead or zinc—usually will equal, if not exceed, that of the original ore. The only way this slime is being handled at present is by flotation, and while this process does efficient work where only one mineral is involved, it will not separate two. At best, one may be recovered; the other lost.

This year much work is being done along hydrometallurgical lines, but at the time of writing no method has been demonstrated a complete success. The most hopeful methods involve leaching with sulphuric acid, for copper ores, and a chlorination treatment for lead and zinc.

The electric furnace has proved its value in refining steel, making alloys, aluminium, etc., and there would seem to be a good field for it in ore treatment. This may be the method of the future, but at present it has not advanced as far as hydrometallurgical methods, combined, if necessary, with electrolysis as a final step.

Denver, Colo.

## Program of Troy Meeting, American Institute of Chemical Engineers

The sixth semi-annual meeting of the American Institute of Chemical Engineers will be held at Troy, N. Y., from Wednesday to Saturday, June 17 to 20, 1914. The technical sessions will be held at the Pittsburgh Building of the Rensselaer Polytechnic Institute and at the Hotel Rensselaer, the latter being the hotel headquarters.

There will be technical sessions on the morning and evening of Wednesday and on the morning and evening of Friday. The following papers will be presented on Wednesday morning:

The Application of Physical Chemistry to Industrial Processes. By W. F. Rittman.

Studies on Filtration. By J. W. Bain and A. E. Wigle.

Scrubber for Vacuum Apparatus for Laboratories. By Chas. Baskerville.

On Wednesday night, Professor M. C. Whitaker will present his presidential address. This will be followed by an illustrated lecture by Dr. Wm. P. Mason on the Saratoga Septic Tanks.

On Friday morning the following papers will be presented:

Shoddy and Carbonized Waste. By L. J. Matos.

The Present Patent Situation. By M. Toch.

Bleaching Cotton Fibre. By J. C. Hebden.

Ozone in Ventilation. By J. C. Olsen and Wm. H. Ulrich.

The program for the Friday night session comprises the following two papers:

Development of Rotary Furnaces. By R. K. Meade.

A Combination Water Softener and Storage Tank. By L. M. Booth.

A great many visits and excursions are scheduled for Wednesday afternoon, the whole of Thursday, Friday afternoon, and the whole of Saturday.

On Wednesday afternoon the laboratories of the Rensselaer Polytechnic Institute and the U. S. Arsenal, where heavy guns are manufactured, will be inspected.

On Thursday morning the General Electric Co. plant at Schenectady will be visited and in the afternoon the filter plant at Albany, besides an automobile trip to Saratoga.

On Friday afternoon an excursion will be made to the plant of the West Virginia Pulp and Paper Company at Mechanicsville. On Saturday morning the Burden Iron Works will be visited where the puddling process for wrought iron will be shown. For the afternoon visits to the Cohoes filter plant (mechanical filters) and to the plant of the Freihoffer Baking Company are scheduled.

Among the social features of the Convention will be a subscription dinner at the Troy Club on Thursday night, a smoker at the residence of Dr. Mason on Friday night, and complimentary luncheons tendered by the Rensselaer Polytechnic Institute on Wednesday noon and by the General Electric Company on Thursday noon.

Professor M. C. Whitaker is President and Dr. John C. Olsen, Polytechnic Institute, Brooklyn, N. Y., is the Secretary of the Institute.

---

Two chloridizing plants are expected to be in operation this month. The first is that of the Northwestern Metals Co., at Helena, Mont., where experimental work has been going on for several years. The other is the Knight-Christensen mill at Silver City, Utah. The details of the process used differ, but the underlying principle is the use of chlorine to render soluble the base and precious metals.

# Light from Unconsumed Electrodes

BY A. VOSMAER, PH.D.

The nature of the discharge which takes place between the electrodes of the arrangement that I shall describe presently has been puzzling every one who has watched it when demonstrated in my experimental laboratory in Holland. The discharge, causing an intense light, is absolutely steady, does not resemble any other, and does not cause any permanent change in the electrodes. In other words, one can obtain a light without consuming the electrodes, which seems something promising in the art of lighting. The discharge itself is not visible, which may be on account of the intense light at the electrodes. Occasionally one is able to distinguish a pale bluish-violet streak—straight, thin, tiny and faint—between the electrodes, but that does not seem to be the essential discharge which produces the effect of light.

The literature on discharges *in pleno* is not very elaborate. Lehmann, Toepler and Warburg have dealt with them at some length, and Lehmann especially has given full information about the subject, but the discharge I shall consider presently does not fall in the class of any of the many discharges mentioned by these investigators. Let us first review the five fundamental discharges *in pleno*, and consider the diagrams given by Toepler[1] in discussing the question of boundary potential differences for different kinds of discharges. Toepler, using a sixty-plate influence machine, distinguishes sharply between the discharge from the positive and that from the negative electrode, and the graphs, Figs. 1 and 2, clearly show the difference in effect. We see a discontinuous line, indicating boundaries between the different discharges; first the non-visible, then the glow, the brush, the spark and the arc.

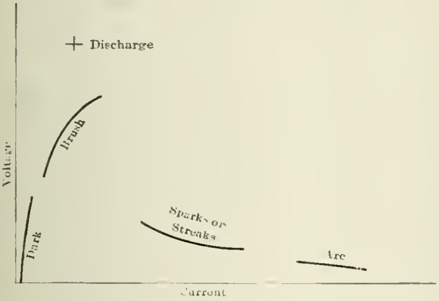


FIG. 1—DIAGRAM OF DISCHARGE

In alternating high-tension discharges, the current being supplied from a transformer, we must place the flame discharge between the spark and the arc. A static machine cannot give flame or arc discharges as transformers do, the current supply being inadequate and the working proper of the static machine ceasing when its electrodes are short-circuited, so to speak, by an arc discharge. The static machine is essentially a high-tension machine; but the flame and arc are essentially low-tension discharges. Consequently this machine is not adapted for the production of such discharges, but for the study of glow, brush and spark discharges it is better adapted than any other.

Toepler observed that in the actual production of the discharges there are no such things as definite boundaries, and he joined the lines by shaded parts. Fortunately he did not give different names to every part. In 1908 Cramp and Hoyle took up the matter again and confirmed Toepler's results. These investigators gave very interesting graphs for the relation of voltage to amperage, of which Figs. 3 and 4 are reproductions. They refer to the low-tension side and to the high-tension side of the transformer, and are an amplification of Toepler's lines.

If we consider the glow to be the beginning of *overcharge*, and hence *discharge*, and the brush the period of regular gentle flow of electricity (from points), and the spark as the result of accumulated charge (from spheres), then the flame and the arc distinguish themselves from these in that they are low-tension phenomena, the others being high-tension discharges. If we take the flame discharge as being due principally to the conductivity of the gas at high temperature, then the arc may be considered as the controlled discharge due to transport of solid matter between electrodes. None of these ways of considering the discharges is correct, but they are given thus for the sake of reference.

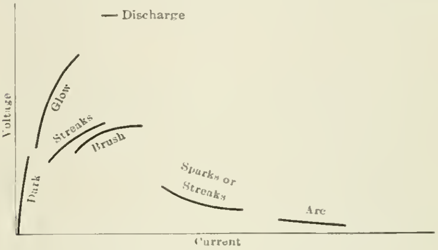


FIG. 2—DIAGRAM OF DISCHARGE

Now the particular discharge under consideration could be called a high-tension arc discharge, because the potential difference between the electrodes is about 500 volts, as against about 35 to 50 for the ordinary arc; but since the arc light is accompanied by transport of solid matter, there is a difference between it and the light under consideration, in which nothing of the kind occurs. Neither is it a flame, a spark, nor a brush. The ill-defined discharge sometimes called "streak" is the only one most nearly resembling it. The peculiar features of the discharge in question are its high tension, viz., about 500 volts; its steadiness; the absence of electrode matter in the flame; the extreme temperature; its sensitiveness to polarity, as well as to frequency when alternating current is being used.

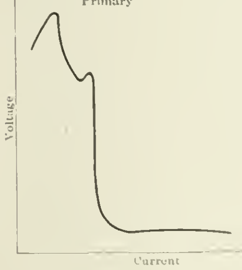


FIG. 3—VOLT-AMPERE CURVE

What is it? That is the question asked many a time, but as yet unanswered. Therefore, it may interest the reader to hear more about it. The production of this very peculiar discharge is simple indeed for those who are accustomed to making experiments, and who have that inborn sense of adjustment of conditions that distinguishes the true experimenter from the haphazard investigator.

---

[1] Ann. d. Phys. 1902, 7, 477.

As the question of polarity plays an interesting rôle in the phenomenon, it is best to take a good-sized Rhumkorff induction coil, preferably equipped with a modern Wagner hammer, allowing of close regulation. We might remind the reader that the induction coil fed by an interrupted primary current will give an alternating secondary electromotive force, due to the difference between the make and the break; but it should also be remembered that the value of said secondary tension depends, for one thing on the *rate* of appearance and disappearance of the lines of force. Now the great self-induction of the coil prevents a rapid "make," but the "break" can be very rapid, indeed, if proper means are provided. A condenser of right size is very important.

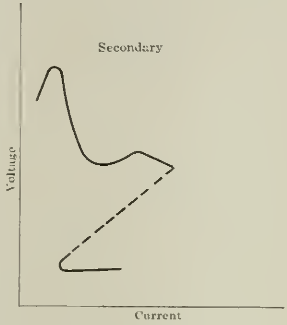


FIG. 4—VOLT-AMPERE CURVE

The great difference in time required for the make and the break, taken electrically, of course, causes a very marked difference in the magnitude of the secondary tension, so marked indeed that we may consider the secondary output to be practically an unidirectional, though intermittent, current.[2]

In Fig. 5 we give a representation of these considerations; the actual rotary mirror photographs look a bit different, but this diagram is true in principle.

As we shall refer to this point again, it may be well to say here that as the difference in polarity of the secondary terminals of a Rhumkoff coil is caused by the great difference in the time of appearance and of disappearance for the magnetic lines of force, the difference can be changed by variation in interruption, as regards speed of working, etc.

Suppose we have this induction coil as we want it, then all we have to do is to join the secondary terminals to an adjustable spark-gap allowing of rapid adjustment of polar distance of electrodes. Now take two bits of pure nickel wire, fix these in said electrodes, and all that remains to be done is to so regulate the different factors that the effect is obtained. The polar distance between the ends of the two nickel wires should be about 2 millimeters to start with. On setting the vibrator to work the ends will burn and form globules. Now adjust (while working) the polar distance until it is about 3 or 4 mm., and when once formed the discharge will go on for any length of time without further adjustment of electrodes. This is one proof that they are not consumed, for if they were the polar distance would be increased and there would not be a permanent condition.

As it is, no such thing as burning occurs. The discharge, when once properly established remains absolutely steady and can be watched and admired. We used to observe it in the cross wires of a telescope and never noticed change of place.

A more stringent proof of non-combustion is that in the spectroscope nothing but a pure continuous spectrum is to be seen, such as belongs to incandescent solid matter. No trace of lines is observed. If there were any transport of nickel, the vapor would show in the spectrum. Now some experimenting has to be done in order to get the right size of wire, corresponding to the size of the coil. My coil was a 12-inch, or a 4-inch spark length; the nickel wires were about 1 mm. for the first and 0.6 mm. for the second.

The explanation of the phenomenon is not easy to give. Probably the surface tension of molten nickel oxide happens to be so great that it maintains a certain volume, and the bombardment of electrons causes it to be white hot.

If, instead of nickel wire we take platinum, the latter will melt rapidly. In fact I have been able to melt or sinter almost anything in this little crater. Such substances as lime or quartz melt easily, but some of the rare earths only sinter.

The mistake of considering a flow of electricity to go from plus to minus is so common that we no longer pay attention to it, everybody knowing it to be the reverse. The best illustration is given by an ordinary carbon arc, wherein the positive, hollowing out to a crater, cannot very well be regarded as emitting particles. It was Armstrong who, in his beautifully illustrated work, "Electric Movement in Air and in Water," showed that current conduction is accompanied by mechanical movement of the conductor, if possible, and in the direction of negative to positive. So we are used to considering the negative electrode as the active, or discharging one, and the positive as the receiving department.

I have more than once drawn attention to the fact that in case we are dealing with true brush discharges it is *not* the negative but the positive electrode that discharges. Warburg holds the opposite view, but Toepler, Przibram, Cramp and Hoyle do not. In the present case, again, it is not the positive electrode that emits the light, but the negative; the positive being quite dark.

This anomaly may be emphasized. The case we first consider is that the electrodes are of the same material and the same size. If the sizes are unlike, say the negative a thin wire and the positive a thicker one, then we do not reverse the light emission but simply have a poor effect.

The effect, as stated, is shown best of all by pure nickel; next come some of the nickel alloys; but other metals do not exhibit the phenomenon in the proper way.

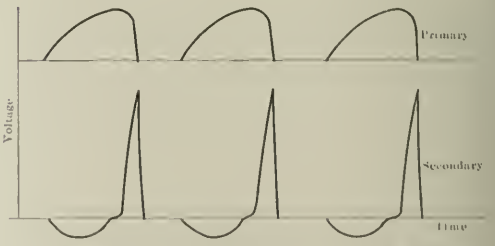


FIG. 5—PRIMARY AND SECONDARY VOLTAGE CURVES

When we feed the induction coil with alternating current or take an ordinary transformer, the effect is that instead of only one of the nickel electrodes glowing, both nickel electrodes will be glowing, as might be expected. But when we now substitute a copper wire for one of the nickel wires the result is that one, viz., the nickel electrode, glows, while the other, the copper electrode, is absolutely dark.

Remembering now what was said about the character of the induction coil's secondary current, we can make another interesting experiment. Upon slowing down the speed of the vibrator (and it is just for this purpose that a hammer interrupter was preferred over any of the more modern kinds) the difference in the rate of appearance and disappearance of lines of force will also fade away, and there comes a moment when the unidirectional character of the secondary tension is lost altogether. At that moment, or period of transition, both of the nickel ends will light up, and on further slowing down it will be possible to have only one of them glow again, but not the same one as in the beginning.

---

[2] Polarity of terminal is easily ascertained by having a strip of moist litmus paper on a strip of glass and holding this between the terminals, the plus shows in red as sharply as the minus in blue.

We must leave it undiscussed whether or not this is due to a change in preference for the negative electrode to glow or to some other reason. The question is very complicated and instead of adding to the elucidation of the difficult problems in discharges it only adds more mystery. As to the commercial side of this phenomenon, it must be remarked that at present the experiments have been made on a very very small scale. Primarily it is a matter of scientific interest; but if we consider the possible value of a light from unconsumed electrodes, whereby all the trouble and expense of trimming is done away with, it seems worth while to investigate the matter on a larger scale and I hope to be able to do so when opportunity offers. For the present, the object of publication is only to communicate a remarkable and unusual discharge phenomenon.

341 St. John's Place, Brooklyn, N. Y.

## Factors Affecting the Cost of Copper

In the annual report of Phelps, Dodge & Company for 1913, Dr. James Douglas, president, makes the following pertinent remarks relative to the company's operations in Arizona, New Mexico and Mexico:

"Judging from the average stability of price during a period of years we may infer that the price of copper in the future will not be lower than realized during the expiring decade. In fact, the price of the future should be higher to compensate for the increase in expense of producing the metal.

"Under legislative enactment and social aspirations the demands of labor will be more exacting, and the taxes, representing the cost of government (municipal, state and federal), will become more onerous. The mines, being always under corporate management, will have to bear more than their share of the burden. The state taxes paid by this company and its subsidiaries have risen from $431,559.76 in 1912, to $605,431.78 in 1913, and federal taxes, amounting to $178,872.84 based on 1913 business, have been levied. The cost of concentrating and smelting can probably be lowered by improvements in both methods and practice, but, with greater depth and the general decline in the grade of ore, the cost of mining will tend upwards rather than downwards; and the inevitable exhaustion of the company's mines must be anticipated and provided for by acquiring additional mining property. With this in view the mines of the Burro Mountain and the Chemung Company in New Mexico have been bought, and additions have been made to the property of the Detroit Copper Company, whose visible reserves have distinctly fallen off. This, fortunately, has not been the case in the Copper Queen and the Moctezuma Copper Company's mines, where the increased activity has resulted in largely increased tonnage of ore in sight."

---

The **P. Wall Mfg. Supply Company**, of 718 Preble Avenue, N. S., Pittsburgh, Pa., has sent us their new, well illustrated catalog on "Wall's Everlasting Steel Specialties," especially brazed steel oilers and torches, steel gong bells, galvanized steel ice cans, sheet metal specialties, copper-plated oilers and torches, etc.

## Tropenas Converters vs. Electric Furnaces for the Manufacture of Steel Castings

By G. Muntz

No one will begrudge the Tropenas converter the honor of having been among the early pioneers who made the steel casting business one of the most important in the world. Steel men are too broad minded to forget those who had the courage of their convictions and made it possible to obtain to-day a product which has become a decided factor in the manufacturing community.

It seems, however, that the fact has been overlooked that although steel as found in channels, I-beams, rails, etc., has almost the same characteristics as the steel that goes to make steel castings, the peculiar conditions inherent to the two manufactures are absolutely different.

We all know what the Tropenas converter can do and it is only necessary to state the claims of the electric furnace used to-day to manufacture steel castings:

1. The metal obtained is lower in phosphorus and sulphur contents than converter steel.
2. Segregation in electric steel is less than in converter steel.
3. Starting with cold steel scrap electric steel is cheaper to produce than converter steel.
4. Absolute uniformity.

We shall not take these claims and criticise them one after the other. We will simply draw a parallel between the Tropenas and the electric process and point out the obvious conclusions as we go.

### RELIABILITY OF THE TROPENAS PROCESS

It is well to define here what we call the Tropenas process. Side blowing is an old idea, and even Bessemer, in his converter at St. Pancras, was blowing through the metal on the side and near the bottom. Adamson, Clapp, Griffith, Witherow, Walrand, Robert, all blew on the side of their converters, but each farther from the bottom. We believe that Tropenas was the first to blow on the surface of the metal or better between the slag and the metal. This principle we think characterises the Tropenas process.

This point being now clear, we want to emphasize the extreme reliability of the Tropenas converter, even when operated by a seemingly inexperienced steel man.

We all know that the Bessemer process and its derivatives alike are first of all ideal means of decarburizing pig iron. A converter cannot be better compared than to an oil lamp. As long as the oil is plentiful, the lamp is burning brightly; when the oil gets low, the flame begins to flicker, and when the oil is almost gone the flame drops. In the converter we burn mainly carbon, a flame ensues which will flicker when the fuel is almost gone and will drop when carbon exists only as traces in the final bath. With a converter the signs indicating the end of the operation are absolutely unmistakable and the blowing itself is so simple that operators can be trained to be most reliable in a very short time. Steel making, by the converter process, depends mainly on good cupola practice whereby suitable metal is secured for refining in the converter. This feature is a decided advantage and must be taken into careful consideration when comparing the Tropenas process to any other.

The electric process, like the open hearth and other similar methods, entails the use of closed furnaces, in which no outward signs are in evidence when the steel has reached the suitable composition. Test bars must be secured at various intervals and the quality of the steel determined in various ways or by direct examination of the fracture.

It is easy to see that the personal equation plays here an important part, and that very experienced men must be secured to properly melt and refine in an electric furnace.

### THE ELECTRIC FURNACE AS A MELTING APPARATUS

Expert melters are scarce and command good salaries. Inasmuch as the electric furnace cannot compete with the basic open-hearth process, as far as cost of production is concerned, and is therefore limited to the small capacities, the resulting business ventures are comparatively small and do not admit of paying the large salaries which the big steel companies can allow to their experts. This is why the electric furnace has adopted the method followed by the old crucible process, whereby the furnace is used as a melting apparatus pure and simple.

The electric furnace has over the converter one great advantage, it can use such material as boiler punchings, turnings, borings, etc., which could not be melted in a cupola, meaning that although it is not as efficient a melting furnace as the cupola it can use cheaper raw material and thereby offset the loss in efficiency to its advantage.

In entering this field, the electric furnace, however, seems to violate the ever-present law of supply and demand. The recent stagnation of the steel scrap market caused such a great difference in prices between steel scrap and pig iron, that temptation might overcome better judgment resulting in the use of more electric furnaces, and consequently increased demand of such steel scrap as cannot be used in the converter process. Statistics show that although steel scrap is to-day at the same level as it was ten years ago, it has fluctuated very widely and often reached such levels as would have rendered the electric furnace a prohibitive melting method.

When determining the cost of liquid metal we find that the factors to be considered are well defined in the converter process, while in the electric furnace the main item, namely, the electric power is a very uncertain quantity. We will disregard the actual amount of current needed to melt 1 ton of steel, as opinions and experiences differ on that score, but there must be considered the cost per unit of the current itself. Steel foundries have given up the idea of manufacturing their own power. The investment required is too great compared to the returns to be expected, and the service offered by the electric companies is so superior that in most cases it is adopted. This advantage is offset by the fact that current is sold according to a sliding scale whereby rates decrease as consumption increases. It is found that in most cases the operation of an electric furnace is prohibitive when the number of operations does not allow the purchase of current at the favorable rates of the scale.

In other words, while a converter can be operated only once without great increase in cost of production, the same cannot be done with the electric furnace except at great loss.

This fact is worthy of consideration especially when one recalls the curtailed outputs which have prevailed for quite some time in the steel casting business.

### UNIFORMITY OF PRODUCT

It is a well-known fact that while melting in an electric furnace the phosphorus and sulphur contents will not increase, but so far as steel castings are concerned these two elements are not of such capital importance. This, however, cannot be said of the carbon contents of electric steel which are not controlled as easily as in the Tropenas converter. In the converter, with operations stopped always at the proper time, absolute uniformity is realized and steels of any carbon contents can be obtained at will by the use of suitable additions. Table I of fifty consecutive blows in two Tropenas baby converters shows what can be expected from the pneumatic process.

In the electric furnace, final additions of ferro-manganese and ferro silicon are made to either obviate oxidation of the metal or to carburize the steel to such an extent as will render it better suitable for the purpose intended, or both. The final product will then contain more carbon than the raw material first used, and inasmuch as at least 35 per cent of the steel poured is returned to the furnace in the shape of gates and risers, the carbon contents will keep on increasing, if delicate refining is not resorted to. However, if the percentage of risers and gates remains about constant, the carbon contents will decrease but only by decreasing increments and will never go over a certain limit.

The obvious conclusion is that the electric furnace as a melter will entail variations in carbon, which will occasion very noticeable changes in the physical properties of the steel produced.

TABLE I—TESTS FROM TWO TROPENAS BABY CONVERTERS BLOWING ALTERNATELY

| Cast No. | Si. | Phos. | S. | C. | Cast No. | Si. | Phos. | S. | C. |
|---|---|---|---|---|---|---|---|---|---|
| 11447 | .26 | .050 | .048 | .220 | 11489 | .23 | .048 | .040 | .208 |
| 11448 | .27 | .055 | .047 | .225 | 11490 | .23 | .046 | 049 | .244 |
| 11449 | .26 | .045 | .046 | .208 | 11491 | .23 | .048 | .048 | .220 |
| 11450 | .28 | .048 | .050 | .215 | 11492 | .25 | .048 | .049 | .215 |
| 11451 | .29 | .050 | .048 | .220 | 11493 | .23 | 050 | .047 | .228 |
| 11452 | .26 | .056 | .054 | .214 | 11494 | .24 | .046 | .047 | .217 |
| 11453 | .30 | .048 | .046 | .218 | 11495 | .31 | .045 | .050 | .220 |
| 11454 | .26 | .050 | .046 | .218 | 11496 | .32 | .050 | .054 | .212 |
| 11455 | .27 | .056 | .048 | .224 | 11497 | .28 | .050 | .050 | .206 |
| 11456 | .28 | .060 | .053 | .240 | 11498 | .32 | .046 | .048 | .210 |
| 11457 | .30 | .054 | .048 | .228 | 11499 | .33 | .048 | .049 | .212 |
| 11458 | .28 | .050 | .046 | .214 | 11500 | .31 | .046 | .047 | .210 |
| 11459 | .28 | .060 | .056 | .200 | 11501 | .31 | .047 | .047 | .210 |
| 11460 | .27 | .050 | .051 | .228 | 11502 | .27 | .050 | .054 | .227 |
| 11461 | .31 | .056 | .050 | .215 | 11503 | .27 | .055 | .049 | .190 |
| 11462 | .28 | .055 | .047 | .200 | 11504 | .27 | .055 | .049 | .190 |
| 11463 | .27 | .050 | .046 | .204 | 11505 | .23 | .048 | .045 | .218 |
| 11464 | .26 | .098 | .044 | .202 | 11506 | .26 | .040 | .045 | .218 |
| 11465 | .28 | .050 | .044 | .210 | 11507 | .25 | .043 | .049 | .198 |
| 11466 | .27 | .055 | .050 | .224 | 11508 | .25 | .043 | .049 | .190 |
| 11467 | .27 | .058 | .052 | 216 | 11509 | .26 | .043 | .045 | .215 |
| 11468 | .30 | .050 | .048 | .220 | 11510 | .27 | .044 | .044 | .230 |
| 11469 | .31 | .050 | .044 | .215 | 11511 | .30 | .044 | .043 | .238 |
| 11470 | .30 | .056 | .049 | .214 | 11512 | .28 | .045 | .046 | .206 |
| 11471 | .31 | .048 | .045 | .198 | 11513 | .28 | 045 | .046 | .206 |
| 11472 | .30 | .050 | .045 | .217 | 11514 | .32 | .045 | .045 | .205 |
| 11473 | .32 | 050 | .047 | 200 | 11515 | .30 | .045 | .050 | 238 |
| 11474 | .25 | .054 | .045 | .228 | 11516 | .27 | .044 | .046 | .238 |
| 11475 | 25 | .054 | 048 | .198 | 11517 | .25 | .042 | .045 | .217 |
| 11476 | .20 | .051 | .045 | 210 | 11518 | .26 | .042 | .045 | .230 |
| 11477 | .27 | .053 | .049 | .196 | 11519 | .23 | .042 | .045 | .232 |
| 11478 | .29 | .050 | .044 | 214 | 11520 | .30 | .042 | .053 | .237 |
| 11479 | .30 | 060 | .053 | 202 | 11521 | .31 | .046 | .049 | .212 |
| 11480 | 31 | .058 | .050 | .196 | 11522 | .30 | .046 | .049 | .212 |
| 11481 | 25 | .064 | .051 | .190 | 11523 | .31 | .046 | .040 | .225 |
| 11482 | .28 | .055 | 052 | .195 | 11524 | .29 | .045 | .050 | .208 |
| 11483 | 27 | .051 | .049 | .194 | 11525 | .28 | 045 | .050 | .223 |
| 11484 | .30 | .050 | .045 | .226 | 11526 | .27 | .050 | .055 | .206 |
| 11485 | .33 | .050 | .048 | .216 | 11527 | .26 | 054 | .046 | .220 |
| 11486 | .30 | .048 | 044 | .200 | 11528 | .26 | 053 | 053 | .238 |
| 11487 | .27 | .046 | .042 | .224 | 11529 | .28 | .052 | .054 | .202 |
| 11488 | 26 | .048 | 042 | .192 | 11530 | .26 | 056 | 049 | .226 |

Average manganese .80 to .90%. Variations in analysis are due to different weights of metal blown without altering weights of final additions. Average weight of blow, about one ton; average time of blow, 12 minutes.

Tests made by Michigan Steel Casting Company of Detroit, Michigan.

### CAPACITIES OF FURNACES

Most of the steel foundries to-day are jobbing foundries and are called upon to produce a great variety of castings, some of which are bulky but made of thin sections, others bulky and heavy, others again small and weighing only a few ounces. To meet the peculiar exigencies of the steel casting business a furnace must, therefore, be flexible and able to produce metal of such temperature and in such quantities as will be suitable for any class of castings. Proper temperature can be obtained in both the electric furnace and the Tropenas converter and either process can produce castings which could not be poured successfully otherwise. Very hot metal can be had at no additional cost in the converter at slight additional cost in the electric furnace. The whole problem reduces itself to one of furnace capacity.

The electric furnace has the advantage over the converter to allow control of the temperature of the metal. This feature is valuable when metal has to be kept in the furnace for some reason or other; once the correct temperature is reached, it can be maintained at slight additional expense.

Metal can be held in the converter but not indefinitely as in the electric furnace. This brings out the fact that the electric furnace is limited in capacity to its own charge. In other words, a 2-ton electric furnace will produce 2 tons of steel every two and one-half or three hours.

If we compare this to what can be done in a converter of equal charge capacity we find that from two to three operations can be made per hour, thereby allowing the accumulation of from 4 tons to 6 tons of steel per hour. We recall the instance of an 18,000-lb. casting being poured successfully with a single 2-ton converter. Six blows were made to secure sufficient metal, each blow being poured on top of the other in a ladle; it took one hour and forty-five minutes to make the steel and after the casting was poured there was not even a skull left in the ladle. This shows that even after waiting almost two hours the steel was still very hot.

This feature of rapidity of operation is one of the great factors in favor of the converter. It reduces itself to the fact that even should an electric furnace be as cheap of installation as a converter of equal charge capacity (which is not the case) it would take five or six 2-ton electric furnaces to produce the work of one 2-ton converter.

### SEGREGATION

The various impurities which are found in steel have different freezing points, and show a tendency to segregate and concentrate in certain portions of large bodies of cooling metal.

This segregation is affected by various factors such as initial temperature of the molten mass and especially the rate of cooling. From experiments made by Talbot in 1905 it was concluded that sulphur segregates most, phosphorus next, then carbon, and finally manganese. It was found also that the usual additions of aluminium reduced the segregation considerably.

Authorities differ as to the elements which segregate first, and Professor Howe shows that carbon segregates the most readily.

It is therefore interesting to apply either results to the particular case on hand.

The field covered to-day by the Tropenas converter and the electric furnace is such that metal manufactured by either process freezes almost instantly after being poured. Small and medium steel castings offer numerous surfaces of cooling and even if the steel produced by the converter process contains more sulphur and phosphorus than electric steel, segregation will take place only in negligible quantities as the rate of cooling is too great to allow any extensive concentration.

On the other hand, if we adopt the conclusions of Professor Howe, segregation will be greater in electric steel inasmuch as carbon has an automatic tendency at being higher than in converter steel.

### INFLUENCE OF LARGE SULPHUR CONTENTS

It is a well-known fact that with sulphur contents up to 0.1 per cent the direct action on ductility and tensile strength is negligible. The only detrimental effect of sulphur is to cause red shortness, or cracking and checking if the steel has to be forged or rolled.

Neither the converter nor the electric furnace contemplate, to any great extent, the manufacture of steel castings which will later be forged. It ensues that higher sulphur contents in converter steel would not prove detrimental to steel castings especially if the manganese contents are properly graduated to offset any possible bad effect due to sulphur.

The only advantage of very low sulphur therefore seems to apply to the rare case of steel castings which have to withstand high temperatures.

### INFLUENCE OF LARGE PHOSPHORUS CONTENTS

Phosphorus is the element which is the most detrimental to steel as it creates brittleness under shock, and general cold shortness. It is the consensus of opinion that phosphorus contents should not exceed 0.08 per cent for all practical purposes. Between 0.05 per cent and 0.1 per cent the elongation and reduction of area are not affected to any great extent while the tensile strength increases. The readings of the testing machine are not therefore of any special value when the effects of phosphorus are considered. Cold bending tests, by use of a drop, are best suited to determine the quality of steel castings, but in the case of phosphorus we find results erratic and capricious and it seems that on this score the best factor to be considered after chemical analysis is the reliability of the producers of the steel.

In the present controversy it must be admitted that the electric furnace has the advantage of being able to use such raw material as will insure low phosphorus contents, but accumulation of phosphorus is very slow in the converter process and the chances of picking it up from fuel, while melting, are very remote. It is, therefore, just to say that converter steel while higher in phosphorus contents than electric steel, more than come within the ordinary limits of safety.

It has been regretted that there did not seem to be any ready market for electric steel castings. The arguments given in the present article might provide a good basis of explanation.

Tropenas Converter Co.,
New York City.

## Award of the Willard Gibbs Medal to Ira Remsen

At a banquet of the Chicago Section of the American Chemical Society, on May 15, the Willard Gibbs gold medal was presented to Dr. Ira Remsen, a founder and former president of Johns Hopkins University. Founded by William A. Converse of the Dearborn Drug and Chemical Co., Chicago, the medal has been awarded before to three other prominent chemists.

In an address on "The Development of Chemical Research in America" Dr. Remsen spoke of the necessity of studying chemistry for the love of the science and commented at some length on results obtained by now prominent chemists who at one time had been his students. Among those at the speakers' table were President George E. Vincent, University of Minnesota, Professor Harry McCormick, Armour Institute of Technology, President Abram W. Harris and Dr. William A. Noyes, Northwestern University.

**Electrolytic Zinc.**—The Borchgrevink electrolytic process for the treatment of zinc ore is to be tried on a larger scale in Norway. Mr. Borchgrevink has succeeded in making his process a success with zinc ore in lime stone containing less than 6 per cent. zinc, so he has been working so far only on a small scale (200 kilograms per doz.). A factory is being built near Kristiania and is expected to be ready in September, with a capacity of one ton per day.

## Paul Héroult

Paul Héroult, the famous pioneer of the electrometallurgy of aluminium and steel, died in Paris on May 9, at the age of only fifty-one years. He had been in poor health for the last few years, suffering from kidney trouble, yet to his many friends on this side of the Atlantic the news of his death came as a sudden unexpected shock.

Paul Louis Toussaint Héroult was born at Thury-Harcourt (Calvados, Normandy) on April 10, 1863. Since his grandfather lived in England he spent his youth's happy days partly in France and partly in England. He was educated at the Lyceum of Caen, Normandy, and later at St. Barbe in Paris, where he graduated in 1882, to enter the Paris School of Mines (Ecole des Mines). From 1883 to the beginning of 1884 he served in the French army and then returned to the School of Mines, but on account of the death of his father he was soon forced to quit his studies in order to conduct the business of his father's tanning works.

However, Héroult continued there his metallurgical researches. He was particularly interested in the electrochemical production of metals. He bought a small Gramme dynamo of 1.5 hp, which he replaced in 1886 by another small machine giving 800 amp at 15 volts. This machine was especially built for his aluminium process, for which he had applied for patents in the same year. In 1887 he became technical manager of the Neuhausen aluminium works of the Swiss Metallurgical Company, where his process is in use up to the present. He then started an aluminium plant in France, at Froges, Isère, for The Société Electrometallurgique Française. About the same time he made two trips to this country, where meanwhile, independently of, and simultaneously with him, Charles M. Hall had worked out what was essentially the same process for electrolytic reduction of aluminium and had started the works of the Pittsburgh Reduction Company.

THE LATE PAUL HÉROULT

After his return to France, Héroult assumed the management of the Froges works, but after the erection of a larger water-power plant in La Praz, Savoy, he became general manager of these new La Praz works. In 1892 the power developed at La Praz was 3000 hp, which was increased to 13,000 hp in 1895.

Héroult's aluminium furnace, which by the addition of a tap hole was rendered a continuous apparatus, became in his hands the instrument for numerous further researches. In it he made the first commercial calcium carbide produced in France. In it he undertook for the Société Electrometallurgique de Froges, the manufacture of artificial corundum, ferrosilicon and ferrochrome, and thus he was led to the researches on the use of the electric furnace in the iron and steel industry to which the balance of his life was chiefly devoted.

In 1904 Héroult came again to the United States to attend the St. Louis World's Fair, and since that time he resided alternately in this country and in France. The American rights of his electric steel furnace which made rapid progress in Europe, were acquired in 1910 by the United States Steel Corporation. With respect to the reduction of iron ore in the electric furnace, Héroult assisted Dr. Haanel's Canadian government investigation at Sault Ste. Marie and also helped in the early work of the Noble Electric Steel Company at the place named in his honor, Heroult-on-the-Pit in Shasta County, California. He later became consulting engineed for the new works of the Southern Aluminium Company, in course of erection at Whitney, N. C., but his failing health forced him to retire. He went to Paris, where he lived the last few years. He was married twice and leaves a widow and five children.

Especially through his connection with the aluminium industry Héroult accumulated a very considerable fortune. Many honors were bestowed on him; the Institute of Technology of Aachen, Germany, conferred on him the honorary degree of Doctor of Engineering; France gave him the red ribbon of the Legion of Honor and the Grand Lavoisier Medal. He had many ardent friends in this country and was a member of the American Electrochemical Society and The Chemists' Club. At the meeting of the New York Sections of the American Electrochemical Society, the American Chemical Society and the Society of Chemical Industry, held on May 22, Dr. C. A. Doremus spoke as follows in proposing a resolution in honor of Héroult's memory:

"Voyagers of old made new maps of the earth. Héroult, the pioneer in metallurgy and engineering, has staked out new fields for his successors to develop. The visions of linking the two great oceans across the Isthmus have only been realized after centuries, but in the span of a quarter of a century Héroult brought to successful practice two epoch-making discoveries. Nor did he rest content with these.

"He showed us how to release aluminium from the bondage in which it has been held for geologic eons; he utilized it in the arts; he gave it to us for the treatment of steel and then carrying forward his intelligent use of the electric current not for electrolysis this time, but for thermic results, has founded a new art in the purification and treatment of the metal for which his age is named.

"Héroult was original, imbued with the ardor characteristic of youth, he was intrepid, resourceful, persistent, and reduced his inventions to practice, in ways that brought him international recognition. And then what a man!

"Whoever had the good fortune to meet him must have been impressed with his modesty, yet also with his latent power; with his cosmopolitanism, yet pride in his native land; and above all with that genial nature that endeared him to his friends and to professional brothers."

A resolution was adopted conveying to the widow and children the most heartfelt sympathy of the members of the three societies and the assurance of their esteem and affection for Héroult as a man, their gratitude to him for the wonderful inspiration he gave to all, working as he did for science and industry.

An appreciation of Héroult as a pioneer of electrochemistry will be found on our first editorial page.

# A Study of the Annealing Process for Malleable Castings

BY OLIVER W. STOREY.

This article gives the results of experimental work carried out by Mr. E. L. Leasman under the author's direction at the Chemical Engineering Laboratories of the University of Wisconsin. Although these experiments were preliminary in nature as a basis for extended work, interesting results were obtained.

Malleable cast iron is a product of importance. The annual production of the United States is over 1,000,000 tons. And yet, in such an important industry scientific progress has been slow. Each malleable iron plant makes its product under different conditions, and, as a result no two products are exactly alike except that all usually have to meet standard specifications.

The lack of scientific knowledge of this industry is made evident by the sparsity of the literature. The only book on this industry known to the writer is Richard Moldenke's recent work, "The Production of Malleable Castings." In the preface he states, "of the closely held secret processes of the great iron industry none can rank with the production of Malleable."

The first record of the process is by Reaumur, in 1722. It is probable that the malleablizing process was practiced much earlier, but, no doubt, it was like so many of the earlier industries, and was a secret which was handed down from father to son.

The pioneer manufacturer in this country was Seth Boyden, of Newark, N. J., who, although he did not discover the underlying principles involved, recorded his experiments. These are the first we have and he deserves special credit since they were made at a time when scientific experimentation on industrial problems was frowned upon.

Malleable iron occupies a position between ordinary cast iron and cast steel. It has a higher tensile strength than cast iron, but not as high as that of cast steel, while its resilience is superior to either.

The method of producing malleable castings is fairly uniform throughout the country. The white iron castings are packed in rolling mill scale in rectangular containers. These containers, either three or four high, are carefully luted up to exclude currents of air, placed in the ovens and heated to the desired temperature, being kept at the high point at least sixty hours. The total time of the annealing process is a week from one time of "lighting-up" to the next time.

The experimental work was carried out to determine the effect of the following variables upon the annealing process.

1. Packing materials.
2. Temperature of annealing.
3. Time of annealing.
4. Rate of cooling.

This was undertaken as a metallographic problem. All specimens were studied with the microscope which showed the structural changes.

In making malleable cast iron, white cast iron is used for the hard castings. This white iron must analyze to within certain limits to insure proper annealing. It is then annealed at the proper temperature, usually between 750° and 900° C., depending upon the practice, for about 60 hours, after which it cools slowly.

The structure of such a white cast iron is shown in Fig. 1. The two constituents shown are the white cementite and black pearlite, which is an eutectoid of ferrite and cementite. The cementite or iron carbide, $Fe_3C$, is present in two forms; first, as excess, and second, associated with ferrite as pearlite.

After being annealed at the proper temperature and slowly cooled the interior structure is usually that of Fig. 2, ferrite and temper carbon, with an outer shell that may vary from a pure iron to a high carbon steel. Fig. 3 is the fracture of a test lug, showing the black heart with an outer bright steel rim.

It is evident that the formation of the malleable structure of ferrite and temper carbon is due to the breakdown of the iron carbide into its elements, iron and carbon, at the annealing temperature, according to the following equation:

$$Fe_3C + \text{heat} = 3Fe + C$$

This reaction explains the formation of the black heart but not the rim structure. A different condition is necessary to produce a pearlite shell than to produce one of pure ferrite. Three different rims are shown in Figs. 4, 5 and 6. Fig. 4 is the rim structure of the fracture shown in Fig. 3, and shows a medium carbon steel area covered by a thin skin of ferrite. Fig. 5 shows an outer rim of nearly pure pearlite, while Fig. 6 shows one of pure ferrite.

The four variables mentioned determine the structure of the casting. The packing materials will affect the rim, while the time and temperature of annealing and rate of cooling will determine the interior structure, with only a minor effect upon the rim.

The white iron used for the experiments was kindly furnished by the Beaver Dam Malleable Iron Company. The material was in the shape of test bars ¾ x ¾ x 10 inches. Mr. W. G. Grimer, chemist for the above company, furnished the following analysis with the bars:

| | | | |
|---|---|---|---|
| Total (combined) carbon... | 2.60 | to | 2.70% |
| Silicon .................... | 0.65 | " | 0.70% |
| Sulphur ................... | 0.055 | " | 0.060% |
| Phosphorous .............. | 0.140% | | |
| Manganese ................ | 0.27% | | |

Fig. 1 is a micrograph of the white iron used. The structure shows a high percentage of pearlite owing to the low percentage of carbon resulting from steel additions to the melt.

The annealing furnaces used for these experiments consisted of two muffles electrically heated by resistance wire. A low voltage regulating transformer gave absolute temperature control.

All thermocouples used were calibrated frequently against a standard platinum, platinum-rhodium couple.

In order to carry on a larger number of experiments in this preliminary work a number of small containers were made. Several could be used in the furnace at the same time. These containers were made of 1½-inch pipe, cut long enough to take specimens 2 inches in length. They were then luted with fire clay except where caps and nipples were used. The serious objection to these small containers was that the oxygen of the air usually had access to the specimen.

### Effect of Packing Materials

The first variable to be studied was the packing material. It had been noticed that certain specimens of commercial malleable iron had an enveloping skin of steel (Fig. 5), others pure carbonless iron (Fig. 6), while others showed an intermediate structure (Fig. 4). It was thought that the packing material would determine the structure of the outer shell.

A large number of packing materials were used, including lime, sand, alundum, rolling mill scale, resistor carbon, manganese dioxide, cement, fine and coarse fire clay, iron oxide, alumina, fine graphite and carborundum.

The results obtained by the use of these various materials showed that their physical and chemical constitution influenced the skin structure of the annealed casting. The packing material had no apparent effect upon the interior in the American "black heart" practice.

The chemical composition of the packing material was a factor that partly determined the nature of the outer portion of the annealed casting. With the materials which were stable at the annealing temperature the structure was uniformly a layer of ferrite. With oxidizing materials a deep layer of ferrite was formed. It is probable that enough oxygen was liberated to decarbonize to a greater depth.

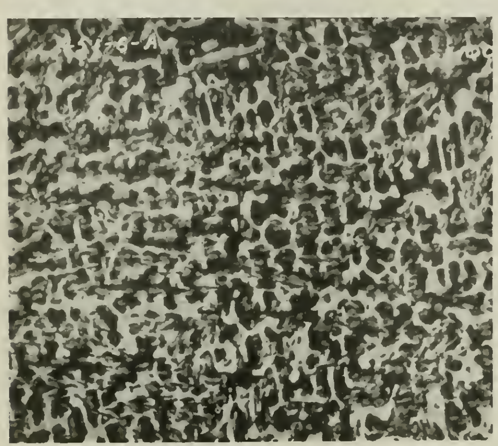


FIG. 1—MICROPHOTOGRAPH × 100

With carbon, charcoal, graphite and case carbonizing materials, a skin structure was formed which varied from a low-carbon to a high-carbon steel.

The physical structure of the packing materials also affected the malleable skin structure. Materials which were loose and porous and allowed a free circulation of the air showed a ferrite exterior. Without the oxygen of the air the structure of the exterior portion did not differ from the interior. This was best illustrated by the following experiments.

Brass turnings were used as a packing material in one of the containers. The brass fused at the annealing temperature and completely inclosed the specimen, preventing the oxygen from coming in contact with the exterior of it. Although a normal malleable structure was formed in the other specimens annealed in the same heat, the temper carbon extended to the brass coating which had formed on the specimen.

That the chemical composition of inert packing materials has little effect on the rim structure is evident from samples of commercial iron. Specimens from various plants using mill scale as a packing material showed a rim structure varying from pure ferrite to a high carbon steel. It is probable that the atmosphere of the furnace and the looseness of the packing rather than the chemical action of the scale determined the rim structure.

The experiments were not carried far enough to determine under what conditions the various degrees of carbonization could be obtained. Even if results were obtained these could hardly be comparable with those obtained in malleable practice. The atmosphere of the experimental furnace was highly oxidizing as compared with that of the commercial furnace. The small containers also allowed a quicker penetration of oxygen than those used in commercial practice. The probable exception was in the use of unusual materials such as case carbonizing mixtures.

But with materials such as mill scale, sand, clay, cinders, ashes, etc., the exterior structure will depend upon the composition of the atmosphere in the furnace, upon the annealing temperature, the method of packing, and the rate of cooling.

The writer recalls one malleable plant where scale is regularly used when the furnaces are running at the normal rate. But when a rush comes anything within reach is used as a packing material, usually ashes and cinders. No difference in structure is apparent between the two malleable products.

In another plant brick dust is replacing scale with no apparent change in structure. Large castings are annealed by merely heating in a muffle, care being taken to prevent excessive oxidation. The structure is the same in all cases, consisting of an exterior layer of ferrite, or pearlite, or both, and an interior of temper carbon and ferrite.

The skin structure, when a neutral atmosphere is used, does not differ from the interior since the breakdown is the same throughout the specimen. This was shown by the specimen annealed in brass. This shows that a slightly oxidizing action is necessary to secure a steel rim and that either a too highly oxidizing or a neutral atmosphere will give a ferrite or a ferrite and temper carbon rim, respectively.

The rate of cooling also has a slight effect upon the skin structure. A slow rate of cooling tends to result in a ferrite rim. This will be discussed later.

Where a case carbonizing mixture was used as the packing material the rim resembled the original iron (Fig. 11), since some of the excess cementite remained undecomposed. This structure will also be discussed later.

A peculiar rim is shown in Fig. 12. Here two steely strata are seen with a ferrite structure between them. Only one specimen showed such a structure.

The following conclusions may be drawn:

1. The packing material does not influence the interior of "black heart" malleable cast iron.

2. The ordinary packing materials do not directly affect the skin structure of malleable cast iron.

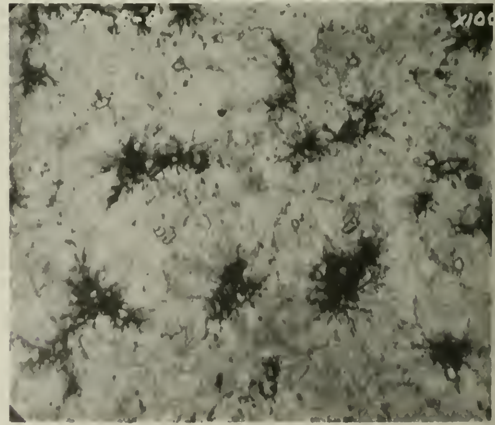


FIG. 2—MICROPHOTOGRAPH × 100

3. A loose packing material allowing a free circulation of oxidizing gases will result in a carbonless rim.

4. A slightly oxidizing atmosphere will result in a steely rim.

5. A neutral atmosphere will result in a rim having the same structure as the interior of the iron.

6. A slow rate of cooling will tend to result in a rim of ferrite.

### Effect of Temperature of Annealing

A number of experiments were run to determine the most effective annealing temperature for iron of the analysis given, where the time of annealing was 50 hours and the cooling to 250° C. took 50 hours.

| *Experiment No.* | *Annealing Temperature* *Deg. C.* |
|---|---|
| 4 | 815° |
| 5 | 760° |
| 6 | 700° |
| 7 | 730° |
| 9 | 840° |
| 10 | 790°–800° |

### Results

The specimens annealed at 700° were too hard to saw though slightly malleableized.

The specimens annealed at 730° were sawed with difficulty. Upon examination with the microscope the structure had broken down slightly.

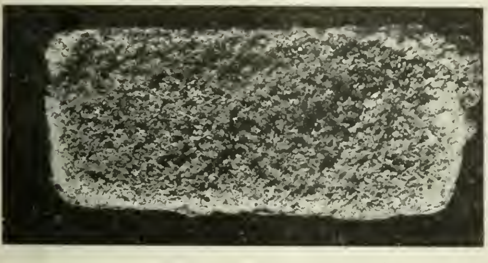


FIG. 3—MICROPHOTOGRAPH × 2½

The specimens annealed at 760° showed a partial breakdown of the cementite, as shown in Fig. 7.

Specimens annealed in experiments 4 and 10 showed but a partial decomposition of the cementite.

Upon annealing at 840° the carbide was almost entirely broken down (Fig. 8).

In one experiment the temperature was kept at 535° to 650° F. for 120 hours, but these specimens were too hard to saw.

In the first experiments an annealing temperature of 870° to 900° was maintained for 50 hours, and this resulted in a complete breakdown of the cementite. (Fig. 6.)

The effect of the temperature is an important factor. Not only does the time of the anneal, but also the quality of the resulting product depend upon the temperature. It is possible to cut down the time of the anneal by raising the temperature, but woe befalls those who do it. A poor product results. The lower the temperature of the anneal the better the product. The balance must be found between the increased value of the improved product and the high cost of the longer anneal.

Figs. 2, 6, 7 and 8 are micrographs of structures of malleable iron annealed at varying temperatures. Fig. 7 shows the result of annealing at 760°. The micrograph shows areas of cementite in a background of ferrite with a few particles of temper carbon. The dendritic structure of the cementite is visible. This shows that the cementite in the pearlite suffers the first breakdown and that the excess cementite is the last to dissociate.

By annealing at 840° the structure of Fig. 8 was obtained. Small particles of undecomposed carbide are still visible though the specimen is composed mainly of ferrite and temper carbon.

Fig. 2 is a micrograph of some commercial iron and shows small areas of cementite. Most commercial malleable iron shows such areas, indicating that the annealing was not entirely completed.

In Fig. 6 the structure is entirely ferrite and temper carbon, indicating that the breakdown at 870° was complete.

### Conclusions

1. With an annealing time of 50 hours the white iron furnished required an annealing temperature of 860° to secure a complete breakdown of the cementite.

2. Annealing at 740–760° for 50 hours resulted in a partial breakdown. By continuing the heat to double the above time it is probable that a complete breakdown could have been secured.

3. No decomposition could be observed in specimens annealed below 670°.

### The Effect of Rates of Cooling from the Annealing Temperature to 250° C.

In all malleable iron work one of the most important factors is the rate of cooling. In the anneal the cooling is slow, usually requiring from 40 to 60 hours. If the cooling is too fast a hard, brittle, steely structure results.

In this research the result of the different rates of cooling was noticed in the first three experiments. When the rate was slow, that is, the drop from 900° to 670° required 38 hours, the interior of the specimen showed an excellent malleable structure, ferrite and temper carbon. (Fig. 6). When the same drop in temperature required but 22 hours, the resulting interior structure showed ferrite, temper carbon and areas of pearlite. (Fig. 9.) When the time occupied but 15 hours the interior showed pearlite, temper carbon, and a small amount of ferrite. (Fig. 10).

From these data it was evident that the structure of the resulting anneal was dependent upon the rate of cooling. It was not only desirable to determine the most suitable rate of cooling, but also to obtain the critical range through which this cooling had to be slowest.

The $A_1$ temperature, 700°, was regarded as the critical point. At this point the transformation of austenite into pearlite occurs. The experiments were run so that the critical range was above 670°, allowing for a lag of 30°.

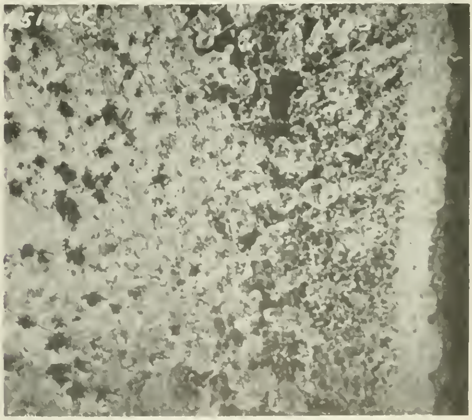


FIG. 4—MICROPHOTOGRAPH × 30

In experiment No. 11, the first of this series, the furnace burned out and the time of cooling was rapid, requiring 14 hours to drop from 870° to 250°. All specimens showed an interior of high-carbon steel and temper carbon similar to that of Fig. 10.

In experiments No. 12 to No. 16 the time of cooling from 870° to 750°, 750° to 670°, and 670° to 250° was varied.

From these experiments one conclusion was drawn. The rate of cooling from 670° to 250° had little, if any, influence on the structure. Though the evidence was inconclusive the work done so far indicated that the rate of cooling from 840° to 730° determined the re-austenite will be precipitated in that range.

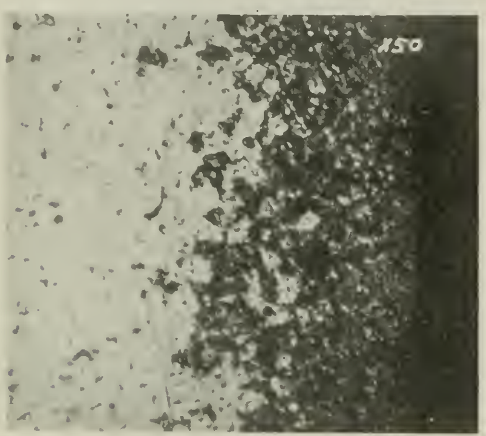


FIG. 5—MICROPHOTOGRAPH × 50

When the malleable iron made in these experiments was reheated for 10 minutes the carbon did not go into solution below 800° and form a steel with air cooling. A slight amount of carbon went into solution when heated for 1 hour at 800°. If the malleable iron was heated at 850° enough carbon went into solution in a few minutes to form a high-carbon steel. This experiment showed that the carbon could not precipitate out entirely above 800°, and that the critical range was below that temperature.

Specimens which had been heated to 900° and consisted of pearlite and temper carbon were annealed at 700° for various periods of time and cooled in the air. When heated to 700° for one-half hour part of the pearlite was decomposed and a narrow band of ferrite surrounded each particle of temper carbon. When heated for 2 hours about one-half of the pearlite was decomposed and the temperature resembled Fig. 10, though the outlines were not as definite. By heating the specimen for 5 hours at this temperature all of the pearlite was decomposed and structure again consisted of ferrite and temper carbon. This experiment would seem to show that the final breakdown of the cementite may occur above the $Ar_1$ point. At the present time the effect of heating at temperatures above and below 700° has not been studied.

It was noticed that particles of undecomposed excess cementite remained unchanged throughout these heat treatments showing that it was stable in comparison with the dissolved cementite.

If the temperature necessary to entirely decompose the iron, iron-carbide solution was below 800°, and if the reaction was negligible below 670° it was evident that a good structure could be obtained by holding the specimens at the critical temperature upon cooling for the correct length of time and then cooling at a quick rate. It was also evident that a good structure could be obtained by annealing at this critical temperature and cooling rapidly. This was done, and although the time required was longer, owing to the lower temperature, a good structure resulted.

The temperature of the final precipitation of carbon is probably dependent principally upon the silicon and manganese content of the iron. The lower the silicon content the lower the temperature at which the iron carbide is stable.* The proportion of these elements will determine the critical range of the iron.

### Conclusions

1. A fast rate of cooling after annealing results in a steely structure.
2. The critical cooling range is between 740° and 830°.
3. If the rate of cooling is sufficiently slow in the critical range all of the carbon in the undecomposed austenite will be precipitated in that range.
4. If the carbon is entirely precipitated in the critical range the rate of cooling below 700° has little effect upon the iron.
5. Very slow cooling will result in a ferrite rim.

### Time of Annealing

A number of experiments were run to determine the correct time of annealing at various temperatures. The results showed that a malleable structure was obtained in 36 hours at 870°. By raising the temperature to 985° the time was cut to 18 hours, while at 740° the necessary time was more than 70 hours.

Though the short, high temperature anneal looks attractive it is not practicable owing to several reasons. It soon ruins the furnace, burns the saggers, and results in a poor grade of malleable iron. The lower the temperature of anneal the cheaper the upkeep of the furnace and the better the iron. Though the best product results from the 740° anneal, this low temperature is usually prohibitive where cost must be considered, owing to the length of time.

### Reactions In the Annealing Process

A metallographic study of the specimens showed the successive reactions occurring in the process. The following data are significant in determining the reactions resulting in the malleable iron structure:

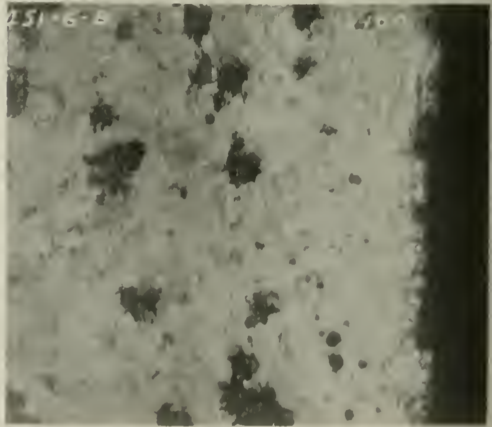


FIG. 6—MICROPHOTOGRAPH × 100

1. When the malleable iron was heated for too short a time or at too low a temperature and slowly cooled the structure consisted of ferrite, cementite and temper carbon. (Fig. 7.)

---

*Charpy and Cornu Compt. rend. 157, 901

2. By increasing the time at the maximum temperature or increasing the temperature the cementite areas were almost (Fig. 8) or entirely eliminated. (Fig. 6.) The structure then consisted of ferrite and temper carbon.

3. By annealing at the proper temperature to insure the breakdown of all of the excess cementite, but cooling rapidly from this temperature, the structure of Fig. 10 resulted. This consists of temper carbon surrounded by ferrite, in turn enveloped by pearlite.

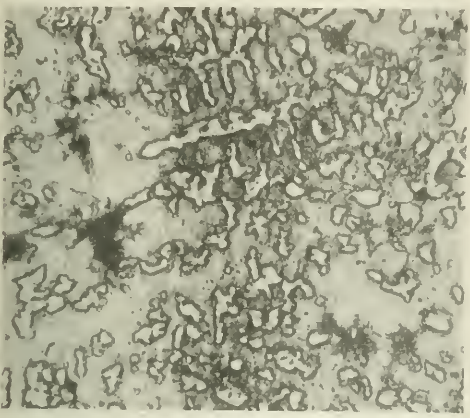


FIG. 7—MICROPHOTOGRAPH × 100

4. When the rate of cooling was slower than in No. 3 the structure of Fig. 9 resulted. This is similar to Fig. 10, but the pearlite areas are much smaller.

5. By annealing at too low a temperature and cooling rapidly the specimen consisted of areas of excess cementite surrounded by pearlite and small particles of temper carbon surrounded by ferrite.

6. When the malleable iron was reheated to about 800° the temper carbon started to go into solution.

7. It was possible to secure a complete decomposition of the dissolved cementite at 700°.

From these data the mechanism of the formation of the malleable structure could be deduced.

The white iron consisted of cementite and pearlite. When heated to the annealing temperature this pearlite went into solid solution as austenite.

It is a question whether the breakdown of the cementite occurs directly from the excess cementite or whether it occurs from the iron carbide dissolved as austenite. Though the research did not result in any definite conclusions, it seemed to indicate that the excess cementite did not break down directly, but that it first went into solution as austenite, from which the carbon was precipitated.

If the excess cementite of the white iron broke down directly the reaction should show some free graphite scattered in areas of cementite, since the decomposition would proceed uniformly throughout the carbide particles. Instead of a uniform breakdown and the scattered formation of temper carbon these cementite areas grow smaller as though they were being gradually dissolved, while the temper carbon forms in large patches. There is no indication of a direct decomposition of the excess cementite.

If the cementite in the austenite decomposes and deposits the temper carbon the ferrite liberated will dissolve the excess cementite. The presence of the nucleus of temper carbon probably causes a more rapid breakdown of the dissolved carbide.

In the specimens examined in which excess cementite remained owing to imperfect annealing, it was found that the cementite adjoining temper carbon areas was usually much smaller than that farthest away. Usually the area directly about the temper carbon was free from cementite. This would be the result if the carbide in the austenite decomposed. Owing to the liberation of the ferrite at the temper carbon the concentration of this consituent would be greatest there and the excess cementite in the immediate vicinity would be more quickly dissolved than that farther away.

The stability of the excess cementite in the white cast iron is shown again in Fig. 11. This specimen was annealed in a case-carbonizing mixture and the exterior portion retained the greater part of the excess cementite. Temper carbon and ferrite were also present in this rim. The interior showed a good malleable structure. In this case it is probable that the carbon necessary to replenish the austenite due to the decomposition of the dissolved carbide was obtained from the carbonaceous gases of the case-carbonizing mixture instead of from the cementite areas. The temper carbon in this rim was not surrounded by ferrite, but was scattered throughout the cementite areas, showing that the latter was more resistant than the gases to the dissolving action of the ferrite liberated at the temper carbon.

The decomposition of the iron carbide in the austenite is not complete at the annealing temperature, but is probably complete at 700°. By cooling quickly from the annealing temperature the specimen consists of nearly pure pearlite and temper carbon, or, if a piece of good malleable, consisting of ferrite and temper carbon, is heated to the annealing temperature, part of the carbon is quickly redissolved to form pearlite. By then annealing at 700° all of the carbon may be reprecipitated.

This pearlite formation shows that the stability of the cementite dissolved in the austenite is a function of the temperature, which is determined more or less by the silicon and manganese ratio. The lower the temperature the less stable the iron carbide. The determination of the limiting temperature or where the cementite is completely unstable was not made, but is probably close to the eutectoid temperature, about 725° to 775°. By cooling slowly through this temperature range the iron carbide may be entirely decomposed and ferrite and temper carbon obtained.

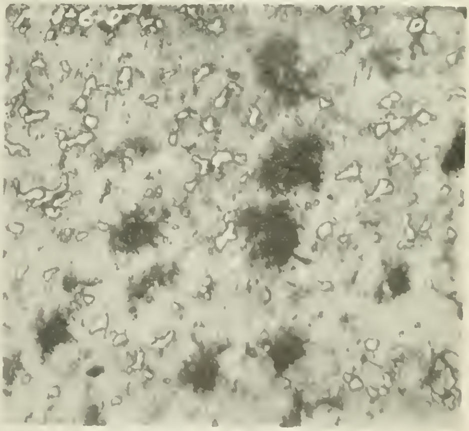


FIG. 8—MICROPHOTOGRAPH × 100

Since the cementite is unstable below this temperature the breakdown of the iron carbide may be possible below the $Ar_1$ point, but the reaction is slower since it is at a low temperature and the carbide is not in solution. Therefore, if the rate of cooling is slow until 650° or 700° is reached, the cooling may be more rapid to the room temperatures. This is corroborated by the experimental evidence.

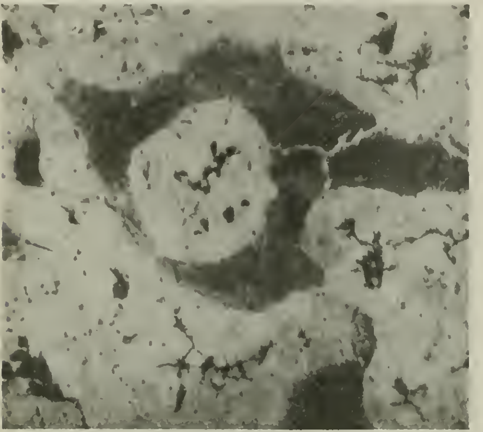


FIG. 9—MICROPHOTOGRAPH × 100

Where the cooling from the annealing temperature is too fast the iron carbide forms pearlite. (See Figs. 9 and 10.) Since the austenite about the temper carbon particles is richer in ferrite the rejection of ferrite takes place here and the pearlite forms furthest from the carbon.

The structure of the rim is also dependent upon the rate of cooling. If the carbon is oxidized from the surface to an extent which will result in a medium to a high-carbon steel, as shown in Fig. 5, and the rate of cooling is slow enough to prevent any pearlitic formation in the interior of the specimen, the cementite in the rim will probably be stable owing to the absence of carbon nuclei. If the rate of cooling is too slow even this cementite will decompose forming a lower carbon steel or a pure iron skin, as shown in Fig. 6. Areas of such partly decomposed pearlite are shown in Fig. 12.

The skin effect has been a much discussed problem. Several different explanations of the disappearance of the carbon, or the decarbonization of the rim of malleable iron, have been offered. Some hold that the carbon migrates to the interior and remains in the casting, while others claim that the carbon migrates out and disappears entirely from the casting. It is obvious that if the carbon migrates out and leaves the iron at the temperature used for annealing, it must do so in the form of a gas. An analysis of the gases formed during the annealing would indicate their nature.

In the hardening and annealing of steels care must be used so that the surface does not become decarbonized. Experience shows how easily and quickly the surface carbon is oxidized. This surface decarbonization is not alone a result of the action of oxygen according to the following reaction:

$$2Fe_3C + O_2 = 6Fe + 2CO$$

$$2CO + O_2 = 2CO_2 \text{ (with excess oxygen).}$$

The surface reaction may also be the result of the action of $CO_2$ on the iron carbide.

$$Fe_3C + CO_2 = 3Fe + 2CO$$

$$2CO + O_2 = 2CO_2$$

$$Fe_3C + CO_2 = 3Fe + 2CO, \text{ etc.}$$

The amount of decarbonization is therefore dependent upon the presence of oxygen and carbon dioxide.

This reaction may be applied to the annealing process. Since the castings are somewhat inaccessible to the furnace gases the reactions and the rim decarbonization are slow. Where the furnace gases have a large excess of oxygen the reaction is more rapid than where less is used. The slower the oxidation the more steely the rim.

Even with a carbon packing it would be impossible to obtain a steel rim at certain low temperatures owing to the equilibrium relations between $CO_2$ and CO. This equilibrium calls for more $CO_2$ at the lower temperatures, and for this reason a casting annealed at a lower temperature, 700–800°, would probably have a more decarbonized rim than one annealed at above 800°. Where a carbon monoxide atmosphere is maintained as in the case of the specimen annealed in a case-carbonizing mixture, no surface oxidation results.

Some experiments were run to determine the gases resulting from the annealing operation. The reducing nature of the gas was shown in a preliminary experiment where a specimen was annealed in cupric oxide. The oxide was reduced, resulting in a mass of metallic copper. Samples of gas, which were being given off by specimens, were then taken and analyzed.

The following gas was taken from a sample being annealed at 870°.

| | *Per Cent* |
|---|---|
| Carbon dioxide | 13.2 |
| Hydrocarbons | 0.0 |
| Oxygen | 8.8 |
| Carbon monoxide | 26.8 |
| By difference, Nitrogen | 51.2 |

A second sample was taken from one annealing at 980°.

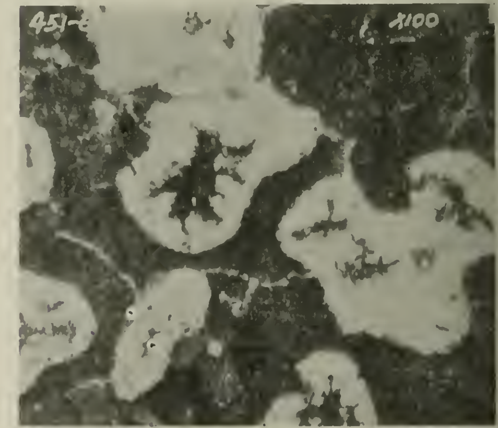


FIG. 10—MICROPHOTOGRAPH × 100

| | *Per Cent* |
|---|---|
| Carbon dioxide | 4.6 |
| Hydrocarbons | 0.0 |
| Oxygen | 3.4 |
| Carbon monoxide | 71.2 |
| By difference, Nitrogen | 20.2 |

The above analyses show that the carbon is removed from the casting as a gas, the composition of the gas depending upon the temperature and oxygen present.

### General Summary and Conclusions

1. This research has resulted in the affirmation of some of the established laws in the annealing of malleable cast iron, namely:

(a) That the packing material does not affect the interior structure.

(b) Slow cooling is necessary to obtain good malleable.

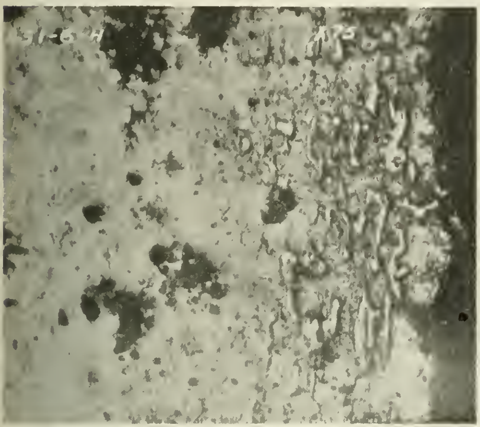


FIG. 11—MICROPHOTOGRAPH × 75

(c) A low temperature anneal gives a much better grade of product than the high-temperature malleable.

2. The conditions influencing the rim structure have been investigated.

3. The result of too rapid cooling has been studied, and is shown to result in a steely structure.

4. The breakdown of the iron carbide has been studied, and though present results are not final all seem to show that cementite does not break down directly, but decomposes from the solid solution or austenitic condition. This breakdown may be compared to the electrolysis or decomposition of a salt. While it would be difficult to decompose a salt in the dry state it is a simple matter to cause decomposition when dissolved in water. The ionic theory calls for a dissociation into ions when such a salt is dissolved in water.

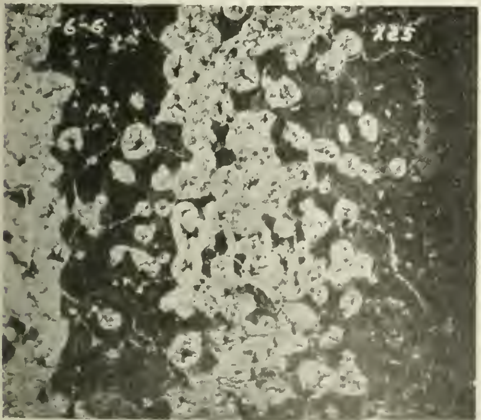


FIG. 12—MICROPHOTOGRAPH × 25

Cannot the case of the decomposition of iron carbide be compared to the decomposition or dissociation of a salt? The analogy is not perfect, but a comparison can be made.

5. The decomposition of the iron carbide is complete above the $Ar_1$ point of the iron-carbon diagram. Whether iron carbide is unstable below the $Ar_1$ point has not been determined.

6. The decomposition of the iron carbide is not complete at the annealing temperature, but is complete in a range of temperature just above the $Ar_1$ point, as given in No. 5.

The author wishes to express his appreciation of the thorough experimental work done by Mr. Leasman, and of the valuable assistance given by the Northern Chemical Engineering Laboratories in the preparation of this paper.

Chemical Engineering Laboratories,
University of Wisconsin.

---

## Wheeling Creek Mine Explosion

### Carbide Lamps Freed from Suspicion

Gas and dust was the cause of the explosion which resulted in the death of Frank Hora at the Wheeling Creek Mine of the Lorain Coal & Dock Company at 2 o'clock, January 27th, 1914.

It was at first supposed that the residue from carbide lamps had caused the explosion; some of this residue was found in break-through 5, about 150 ft. from the center of the explosion. As a preliminary, pending the investigation, a temporary order was issued forbidding the miners of Wheeling Creek Mine to use carbide lamps. The local union passed a resolution demanding a thorough investigation and refused to go to work unless allowed to continue using carbide lamps.

In the meantime Chief Mine Inspector Davies, Deputy Inspector Gaffney, together with Safety Commissioner of Mines Roan, of the State of Ohio, aided by other deputies, officials and experts, were making a most searching investigation. It was soon demonstrated that as the residue left by the carbide lamps is merely slaked lime it could not be considered as a cause and it was proved conclusively that even had there been fresh carbide in the break-through it could not have had anything to do with the explosion as the break-through was dry. Carbide will not give off sufficient gas when exposed to the air to cause an explosive mixture or an ignitable mixture unless brought in contact with actual water. The moisture in the air is not sufficient to make enough acetylene to ignite. There can never be an accumulation of gas produced from carbide by moist air for the obvious reason that in order to produce gas any air which has given up its moisture to produce acetylene must move on and the acetylene goes with it. The careful investigation of the location of the carbide residue showed that as a matter of fact, this residue was shut off from the butt entry in which the explosion occurred by a substantial brattice, the residue being located within 3 ft. of the adjoining butt entry in break-through 5, and, as before stated, with a brattice between it and the butt entry in which the explosion occurred.

When these facts became apparent a meeting of the local union was called. The order prohibiting the use of acetylene was rescinded by the chief mine inspector, his deputies and the Safety Commissioner. The investigation into the actual cause of the explosion continued. The work of the Ohio mine inspectors and the Safety Commissioner was supplemented by an investigation conducted by Mr. J. W. Paul of the U. S. Bureau of Mines. It was found that the explosion was caused by an accumulation of methane (fire damp) intensified by dust.

# Determination of Carbon in Iron and Steel

## Direct Method

BY W. D. BROWN.

The essentials for complete combustion are an initial temperature of the furnace of about 1800° F., the burning of the metal in nearly pure oxygen, and an unlimited supply of the latter during combustion. If the metal is pushed into the furnace and a slow stream of oxygen started, combustion will begin before all the air has been displaced and will be in a mixture of air and oxygen; possibly the combustion of the iron will be complete before the oxygen has completely displaced the air and the only work remaining for the oxygen is to displace the carbon dioxide in the tube. When the combustion begins, oxygen should be supplied as fast as the iron will combine with it, that the temperature may be raised to the highest point; about 3000° F. will be momentarily obtained and all the carbon will be oxidized. These requirements of starting combustion in oxygen and an unlimited oxygen supply have been met in the method described below. In addition the supply of oxygen has been made automatic.

*Apparatus.* The electric furnace contains a silica tube ⅞″ in diameter and 24″ long; in it ignited asbestos is loosely placed from the exit end to within 3″ of the middle of the furnace; this acts very well as a catalizer, and is necessary when burning pig iron, at least. Oxygen is obtained in 100 ft. cylinders on which is a pressure reducer and regulator which supplies oxygen at a pressure from 1-3 lbs. as desired. The regulator is connected to brass piping containing four tees and globe valves for four electric furnaces (more could be added as desired), thereby one tank is used for the four furnaces. Oxygen enters the silica tube through one hole of a two-hole stopper. In the other hole is a 12″ copper or glass tube, ¼″ outside diameter; on the end of the tube is a No. 00 single hole rubber stopper. Through this stopper and tube a plunger rod of No. 9 nichrome wire, 24″ long, to which is riveted a sheet of nickel about ½″ diameter, is inserted. This is used to push the boat into the hot part of the furnace after the oxygen has displaced the air and while the current is flowing, and can be made in any laboratory; the No. 00 stopper can very well be replaced by a small stuffing box, in which case the copper tubing is shorter. The oxygen being free from $CO_2$, no purification is necessary. Both ends of the silica tube are cooled by copper water jackets.

The exit end of the tube is connected by a rubber stopper to a glass stopcock, which is used to regulate the flow of gas. The stopcock is connected to a 5″ drying tube filled loosely with phosphoric anhydride. It has been found that a zinc tube is not necessary, as the sulphur trioxide fumes are caught by the asbestos and phosphoric anhydride.

The drying tube is connected by a rubber tubing, on which is a pinchcock, to a Vanier potash bottle. This bottle contains a solution of potassium hydroxide (purified by lime) of 100 grams per 100 c.c. water. The inner tube is filled with phosphoric anhydride and a covering of glass wool placed thereon. Filled in this manner, the bottle will last for 100 determinations. The part which fails first is the phosphoric anhydride; a solution will form in the bottom of the drying chamber and will gradually grow until there is no more dry anhydride; this marks the life of the bottle.

On the construction of the Vanier bottle depends the success of the method; it must be so made that a speed of 400 c.c. per minute may be obtained without the gases passing out the lower end of the inner coil, which can be done if the lower end points or slants downward instead of being horizontal. The exit end of the coil should also be opposite the entrance to the drying chamber to prevent the splashing of the potassium hydroxide solution into the phosphoric anhydride. (Such a bottle is supplied by A. H. Thomas Co.)

*The Method.* A blank is first run in the following manner. With all connections closed, the oxygen is turned on the line and the pressure varied until three lbs. are obtained. One or more bottles are then connected to the furnace or furnaces and the stopper inserted in the entrance of the silica tube, the stopcock in the bottle is then turned, the pinchcock opened, and the globe valves from the oxygen line opened full. Oxygen should then pass through the bottle at a rate of approximately 400 c.c. per minute, the pressure in the line dropping to 2 lbs. If the speed of the gas is not as great as this, the reducing valve should be so regulated as to increase the pressure. It may happen that one bottle will go faster than the other; in that case, the stopcock at the exit end of the furnace is to be partially closed so that all bottles have the same speed. When this condition has been obtained,—the right pressure in the oxygen line and the stopcocks just right, no change is made until it is necessary to renew the bottle or tank. The stream of oxygen is continued for five minutes, the oxygen is then shut off at the globe valves on the oxygen line and, as soon as the flow of gas slackens in the bottle, the pinchcock on the rubber tubing leading to bottle is closed and, when the flow has completely stopped in the bottle, the stopcock is turned, the bottle is removed and weighed, preferably with a tare. This is repeated until the variations between weights is not more than three decimiligrams.

For the actual test, 1.36 grams of steel between 20 and 60 mesh or half gram iron, are weighed and transferred to a groove in alundum contained in a nickel boat. The bottle is connected to the furnace as above and the stopper turned, the pinchcock being closed. The boat is placed just within the silica tube, the two-hole stopper carrying the pusher is then inserted in the tube, the pinchcock opened and the oxygen turned on full at the globe valve. Oxygen then passes through at the rate of approximately 400 c.c. per minute; if the rate varies perceptibly from this it can be regulated by stopcocks at exit of silica tube. After gas has passed through for one minute, the boat containing the drillings is pushed into the center of the furnace by shoving in the nichrome wire mentioned before, while the current of gas continues. In about one minute the drillings have become heated sufficient to burn freely and combustion then is very rapid, being complete in twenty seconds. During the combustion an unlimited supply of oxygen is at hand, as the globe valve is open full and the regulator is set for a definite pressure. The oxygen then passes through to sweep out the carbon dioxide formed, five minutes after the boat is pushed back being sufficient. The globe valve is then shut off and, when the flow of gas has slackened, the pinchcock is closed, followed by the closing of the stopcock as above described. The bottle is disconnected and weighed; increase in weight in grams, multiplied by 20 gives % C. when 1.36 grams steel has been used.

In routine work, one analyst weighs up four (or less) tests, places boats in furnaces and starts the gas flowing. During the one minute's wait, he examines stoppers, etc., for leaks, then pushes boats back and leaves furnaces for other work, returning in five minutes for the completion of the determination. This method can be used for the determination of carbon in steels ranging from 0.07 per cent to 1 per cent carbon, as well as on pig iron. Not only is the accuracy greater than with color determinations, but the time required for analysis by combustion is less than by color.

Duquesne, Pa.

# A Convenient Method for Handling Chemical Solutions in Quantity

BY C. C. PHELPS, M.E.

When acids and other chemical solutions of a corrosive nature must be lifted or conveyed from one place to another, the relative advantages of different methods of accomplishing the desired result cannot be decided on the questions of initial or operating costs alone, for the service may be so severe on certain types of apparatus as to render them practically useless in a short time. Frequent delays for repairing may also occasion great losses due to the stoppage of manufacturing processes. Ordinary reciprocating and rotary pumps are often out of the question, even when constructed of special material of a non-corrodible nature.

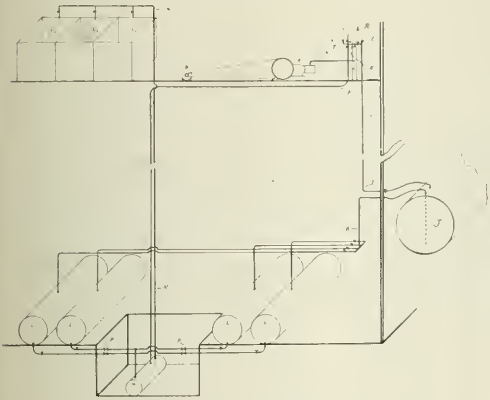


FIG. 1—SYSTEM FOR PUMPING ACIDS

A device known as a montejus, which is operated by either air or steam pressure, has been used to some extent for this purpose and is fairly satisfactory; but it is open to the objection that it has valves, floats and other moving parts in contact with the fluid. Other devices, using air or steam pressure, employ either the injector or siphon principle for their operation with more or less success, depending upon the requirements, but they, too, have certain limitations in practical use.

For handling chemical fluids in large quantities the method illustrated herewith has certain advantages which will be apparent from the description. The system illustrated in Fig. 1 is in use in a large Massachusetts textile mill, for raising heavy commercial oil of vitriol to bleaching vats on the third floor of a building. Compressed air is used, not only for this purpose but also to empty the acid from the tank cars which are brought alongside of the building. The engineers in charge of this plant consider that the method which they have adopted is admirably adapted for its purpose.

Referring to the diagram, $O_1$, $O_2$, $O_3$ are lead-lined bleaching vats; they are partially filled with pure water, after which 100 gal. of the concentrated sulphuric acid is raised and added slowly to the water, the contents being stirred while the acid is being added; then a small quantity of hydrochloric acid is added by hand from a carboy, after which the bleaching solution is ready for use.

Located near the vats is an air compressor *A* driven by a 2½-hp belted motor *B*. The compressor cylinder has a displacement of 15 cu. ft. of free air per minute and operates normally at 40 lb. per square inch air pressure. The compressor, gauge, receiver and controlling valves are shown in the photographic view, Fig. 2.

The compressor discharges into a length of pipe *C* of large diameter, which acts as a receiver to steady the pressure in the line. Gauge *Q* indicates the air pressure in the line. Two air lines, *I* and *F* lead from the receiver. By closing all valves on the left of the receiver outlet and opening valve *R*, pressure is put on pipe line *I*. The latter line leads to a connection whereby air pressure can be put on the tank of an acid car *J*. Safety valve *E* is set for 15 lb. per square inch, so no pressure in excess of this amount can be put on the car tank. The car tank's outlet is coupled with pipe *K* leading from the outside of the building to four heavy iron reservoir tanks *L* in the basement of the mill. Each of the tanks *L* has a capacity of 3,500 gal. and is provided with air vents. With an air pressure of 15 lb., it requires about two hours to empty the car, capacity of which is usually about 5,000 gal.

Pipes lead from the bottom of the reservoir tanks to the top of a 100-gal. iron supply tank *M* placed a few feet below. In each of these connecting pipes is a check valve *P* to prevent the acid from returning to the large tanks. Leading from the top of the small tank is the air pipe *F*. Normally this serves as a vent, allowing the acid to flow into the small tank and fill it. When a charge of acid is wanted, this vent is closed by a valve *S* near its outlet *G* and air pressure is put on this line by opening valve *T*. The acid immediately begins to flow from the bottom of the 100-gal. tank up pipe *N* to the bleaching vat, a height of about 40 feet.

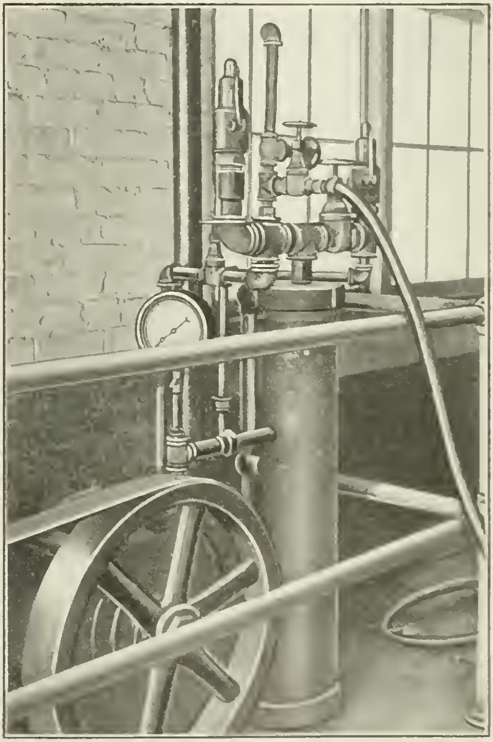


FIG. 2—COMPRESSOR RECEIVER AND CONTROLLING VALVES

About five minutes is required ordinarily to pump the 100 gal. wtih an aair pressure of 40 lb. Saafety valve *D* is set for 50 lb. per square inch. A short length of hose, *H*, connected to the air system, is used for cleaning and similar purposes.

With this system there is no mechanism to come in contact with the acid and get out of order. Everything is simple. When a charge of acid is wanted, the motor is started by simply throwing over the starting switch; then the proper valves are opened. The charging tank will not deliver more than a hundred gallons at a time, although less than that quantity could easily be obtained by shutting the valve at the vat at the proper time; the air pressure on the tank being constant, the rate of acid flow will, likewise, be constant, and the quantity of acid lifted in a given time will, therefore, be proportional to the time required for raising it. Pressure is put on the line only when actually pumping, hence the economy of operation is marked. The air pressure is on only the small tank and the lines leading to and from it. The larger tanks are never under air pressure and hence any trouble that might develop through leakage in such large tanks is avoided. The acid, being in concentrated form, does not cause any trouble from corrosion in the iron tanks or pipes, as might occur with dilute acid.

The flow of acid by gravity from the reservoirs to the small tank is entirely automatic and reversal cannot occur. No attention is given to the apparatus in the basement, the entire control being where the acid is used. The extreme simplicity of the arrangement described above ought to suggest its use for a large number of industrial processes, perhaps with modifications to suit each case.

Weehawken, N. J.

---

## Sixth International Congress of Mining, Metallurgy, Engineering and Economic Geology

### London, 1915

The Sixth International Congress of Mining, Metallurgy, Engineering and Economic Geology will be held in London from Monday, July 12, to Saturday, July 17, 1915.

An Executive Committee has been formed with Arthur Cooper, LL.D., as chairman; Sir William E. Garforth, LL.D., as vice-chairman; Sir Hugh Bell, Bart., D. C.L., LL.D., as honorary treasurer. Mr. G. C. Lloyd is the general secretary with offices at 28 Victoria street, London, S. W.

There will be four sections, section 1 being devoted to mining (coal mining and metalliferous mining); section 2 to metallurgy (chemical metallurgy and physical metallurgy); section 3 to engineering; and section 4 to economic geology.

Members of the Congress may be:

(a) Honorary members and the official delegates of foreign states.

(b) Supporters of the Congress—that is, members who subscribe not less than £5 ($25) to the Congress fund.

(The above will be entitled to attend all meetings and to receive all publications of the Congress.)

(c) Ordinary members, who pay a Congress fee of £1 ($5), which entitles them to registration in any one of the four sections, to attend all meetings, and to receive the Proceedings of that section in which they may elect to register. They may register their names in, and obtain the Proceedings of the other Sections by making a further paying of 5s. ($1.25) for each section.

The Congress fee for ladies is 16s. ($4).

---

## The Development of Modern Cyanide Practice

BY C. M. EYE., E.M.

In reviewing the rapid advance of the cyanide process for the recovery of the precious metals, one is most impressed by the broadened field of its application to-day as compared with that of the early days of the process. Many of us can remember when its successful application was limited to clean, porous, well-oxidized gold ores, the treatment being by leaching. The primitive method consisted of crushing dry to as coarse a mesh as possible, usually ¼-in. size or coarser, charging dry into shallow tanks with no attempt at separation of fines, and then leaching. The first wetting was by solution put on from below, followed by downward flow of solution, closely followed after the proper period by weak solution, and in this turn by water wash. The principal precaution taken was to avoid the separation of fines or slimes into a layer or layers at any stage of the treatment. The writer's first experience was obtained in a plant of this character, where, in spite of the presence of considerable clay in the ore, better than 90 per cent extraction was obtained regularly.

Following such direct treatment, the next logical development was its application to the tailings from other processes, notably amalgamation, and in this a much greater variation of practice developed. The treatment generally involved double handling, in order to rid the tailings of excess moisture, break up slime layers and render them permeable. In those days, since separate slime treatment was expensive and unsatisfactory, as large a proportion of slime as possible was handled with the sands by leaching. This rendered double handling almost unavoidable. The results on sand were poorer than if the slime had been kept out, but it was a case of choosing the lesser of two evils.

In many cases, however, direct filling and drainage was practiced, with poorer results, it is true, but at less expense. More slime had to be eliminated in this case; if not by previous classification, then in arrangements for securing overflow of slime and excess water as the tanks filled, by superimposed rings in the center as in South African practice, or by plugs and drains in the sides. Of course, the moisture content could not be reduced to as low a figure by direct filling, nor was the charge left as pervious for leaching, being packed after draining. Another difficulty encountered in this method of treatment, more pronounced than in others, was that of aeration to secure the oxygen necessary for extraction. Frequently preliminary treatment was followed by transfer and additional leaching in order to obtain additional oxidation and aeration. Attempts were made to introduce air from the bottom, but these usually resulted in channeling. About every known oxidizing agent was used, first and last, to artificially supply this necessary element, but were usually abandoned because of cost, inefficiency or deleterious effect on solution. The practice of using artificial oxidizing agents has therefore practically gone out, through aeration of solutions now fulfilling this function.

### Steps in Mechanical Development

The mechanics of the earlier developments were simple, the greatest development in connection with leaching methods being reached by the Blaisdell system of filling and emptying tanks by an excavator on the principle of a disk harrow, but this system was and is applicable only to large installations on account of its cost. The revolving sand filter for the preparation of sand for leaching is another extremely important development. These, with the simple but efficient Butters distributor, comprised the more important mechanical developments, until the invention of the submerged slime filter. This opened up an entirely new field for expansion, for it not only furnished a method of separating solution from slime much superior to the decantation method, until then followed for the treatment of slime unavoidably produced, but it led to the general adoption of fine grinding of sand, and the treatment of both together by agitation and vacuum filtration. The multiplicity of patented mechanical devices and methods using this principle led to so much litigation, however, that operators came to regard them all with mingled feelings of uncertainty and disgust, and came to regard vacuum filtration as something to be used when necessary, but to be avoided where possible. It was found also in many cases in practice that the net results from the use of filters were not so great as at first supposed on account of difficulties and expense of operation and upkeep.

Not that vacuum filtration has passed, or is likely to be relegated, by any means, for in many cases conditions are such as to make this the only practicable method of working; but the introduction of continuous treatment has made it possible to dispense with filtration by using other and more simple systems of separation. Foremost in this has been the continuous countercurrent decantation system, using thickeners for obtaining a low ratio of solution to solids, and involving the handling of solution instead of pulp with less power and less expense. The principal objection to this system is that while it affords an ideal means for very complete recovery of gold, it does not admit of as close recovery of cyanide solution without undue building up of stock solution, and for this reason has frequently to be followed by vacuum filtration to avoid heavy mechanical loss of cyanide.

### Upward Displacement in Slime Treatment

A system which rivals this and which is gaining ground, is based on the principle of upward replacement, the barren solution or wash being introduced at the bottom and displacing the solution which it is desired to remove. At first sight it would appear that diffusion would defeat the object sought, but when the displacing liquid is mixed with a thickened pulp at the bottom of a tank (this pulp being constantly added to by settling pulp from above and removed by drawing off constantly from the bottom), the displacement does take place with very little diffusion. It is probable that the proximity of the individual particles of the pulp in a thickened but thoroughly uniform mass, prevents the diffusive action which otherwise would occur. It is noticeable, also, that the diffusion is more pronounced between solutions of different chemical strength, and greatest between clear water and solution, as would be expected. While open to the objection that the use of slime-circulating pumps is essential, the system has several decided advantages: First, that in the replacement of gold-bearing solution, very little dilution of the solution takes place, enabling the metals to be recovered from a smaller bulk. Second, that only a small proportion of the gold is carried forward to the next stage with the pulp, as the solution going with the pulp is mostly barren solution that has been added. Third, that it affords a means of changing from solution of one chemical strength to another, or from water to solution or vice versa, with very little building up of stock or loss of chemicals. This latter point makes for the system two unique uses: First, in displacing water by solution from pulp where the preceding mill treatment is conducted in water, and, second, after cyanide treatment, in displacing solution by water for final discharge.

The extensive adoption of the practice of crushing and grinding in solution, dispensing with the amalgamation or other treatment, has obviated in many cases the necessity of close separation of liquid and solid before the latter enters the cyanide plant, a thickening to the desired degree of dilution for agitation being all that is required. It is here that the continuous countercurrent decantation system has its best application, it being possible to operate the whole plant with one closed solution circuit. But it is not always practicable to crush and grind in solution, owing to possible necessity of amalgamation to recover coarse gold not easily dissolved in cyanide, or necessity of concentrating or otherwise removing from the ore such constituents as would be destructive to cyanide in direct treatment. With these conditions, it becomes essential to remove as much liquid as possible from the pulp before it enters the cyanide plant, to avoid undue accumulation of solution and possible destruction of cyanide by soluble cyanides. It has even been found advisable to use vacuum filtration at this point, reducing the moisture to about 30 per cent, as against a usual 50 per cent by ordinary thickening. Even the 30 per cent remaining which has to be made up into cyanide solution of full working strength in the treatment, may cause a considerable accumulation of solution, and if the principle of upward replacement can be successfully applied here, with a resultant saving in cyanide, it will be a distinct step in advance. It is claimed by those introducing it that it is being so applied, but few data are available as yet as to this use. It is to be borne in mind that thickening is done at the same time, and in the same operation, though somewhat more expensively than ordinary thickening because of the necessity for operating a circulating pump in connection.

### Present Tendency in Agitation

In agitation methods, compressed air is the almost universal agent employed, both on account of its convenience of application, its value in aeration, and its cost, as compared with mechanical agitation, when upkeep of the latter is taken into account. Its use in air lifts as a means of pulp transfer is almost as nearly universal, and for the same reasons. The Pachuca is still the most popular air agitator, being in most cases now operated continuously in a series of several tanks. The extreme height at first thought necessary has been dispensed with in more recent installations, enabling these tanks to be used with less air pressure and equally good results.

Systems using circulating slime pumps are no longer in general use, owing principally to difficulty of keeping up the pumps, and the cost of operation. Modern slime pumps are being built, however, much superior to those of earlier days, with well protected bearings; and when run at proper speeds, and well cared for, with stuffing boxes protected at all times by clear water or solution under pressure, there is no good reason why they cannot be maintained. They allow of one important feature in treatment which is very beneficial, and that is the introduction of atmospheric air in abundant quantity, intimately mixed with the pulp, this air being free from the hydrocarbon compounds resulting from decomposition of lubricants in compression.

Probably the latest successful agitator to be placed on the market combines the mechanical agitator with the air-lift principle of the Pachuca. In fact, several machines have been devised lately on these lines, but with different methods of application. This method may be regarded as the present tendency in agitator construction.

In precipitation, the old, original zinc shaving method of extraction is still used generally in smaller installations and out-of-the-way places, on account of its simplicity; but the perfection of the zinc-dust method, its cleanliness and ease of operation when properly installed, and its better adaptability with solutions weak in cyanide has led to its adoption in the majority of new and larger installations. The newly developed method of precipitation by the use of aluminium is no doubt the most nearly perfect method yet devised. Cleanup and refining methods vary much with the practice in precipitation, but the washing and direct smelting of carefully screened precipitates in oil-fired tilting furnaces covers the majority of cases.

The extension of cyaniding to ores of gold and silver combined, then to straight silver-bearing ores, some of which are very complex, is perhaps the most wonderful feature of the development of the process. Facilities for fine grinding and thorough agitation with air were the principal factors in this. The record made in scores of modern mills makes the chronicle not many years since of a 60 per cent extraction at Chloride, Utah, on ore containing chloride of silver, seem like a tale of the Middle Ages. And that was a record in silver cyanide at the time. Indeed, it is hard to realize how this process has, in twenty-five years or so, displaced to a large extent amalgamation (becoming its chief assistant where it has not displaced it), relegated to the past chlorination and silver amalgamation, and reached out into every part of the globe until it is to-day the most generally recognized and applied of all wet metallurgical processes.

*Los Angeles, Cal.*

## Development of Alaska

The final passing by Congress and signing by the President of the Alaska railroad bill is of interest to the mining and metallurgical industry. The development of a country acknowledged to be rich in mineral resources has long been delayed due to the inability of interested parties and the government to agree on a system under which the public lands should be exploited. Coal lands in particular have been the bone of contention. It is expected that the railroad bill will now be followed by one providing for leasing of coal lands. The provisions may not be all that could be desired, but in the main they are favorable. Comparatively large acreages, 2650 acres, are to be leased, and all the coal therein contained is covered by the lease. Royalties are regulated, above a minimum of two cents per ton, by competitive bidding among the lessees. With the development of coal lands in Alaska there should come an increased interest in its other mineral resources, and the mining industry should develop largely.

## The British Aluminium Company

The fourth ordinary general meeting of the reconstructed British Aluminium Co., Ltd., took place on March 27th, when Mr. A. W. Tait, chairman of the company, presided. He said that the trading profits for the year and the proceeds of investments, together with the revenue from the Kinlochleven & Foyers Estates, amounted to £268,720 5s. 2d., as against £194,823 15s. 11d. in the previous year; and these results are by a long way the best ever accomplished by the company since its original formation in 1894. The increase in the net profits is entirely due to trading and is attributable to increase of tonnage, economy in cost of production and, to a still greater extent, to the higher prices prevailing during the year. These prices, however, had not been abnormal, but have only returned to a reasonable figure after four or five years' depression.

The revenue from the Kinlochleven & Foyers Estates shows a decrease of £906 6s. 8d., as compared with the previous year, which is almost wholly due to unusual expenditure connected with the village at Kinlochleven, which was necessary for the housing of the workmen. Additional plant has been put down at the Aluminium Works at Vigelands, Norway, from which an increased production for the present year is expected.

The large increase in the productive capacity of the company's aluminium works has made it necessary to correspondingly increase the capacity of the works for producing alumina. Last year the company acquired a half-interest in the works of the Bauxite Refining Company at Hebburn-on-Tyne, but the increase so obtained is not now sufficient to meet present or future requirements, and arrangements have been completed to acquire about 38 acres at Burntisland, Scotland, where the conditions of labor supply and shipping facilities are favorable. To ensure a good supply of bauxite a quantity was acquired from the Union des Bauxites and has been deposited on land in the name of the company. This will form a reserve stock, only to be used to supplement regular supplies from the subsidiary company. The company's rolling mills at Milton, Staffordshire, have been employed up to their full capacity during the whole year. The new mills at Warrington, Lancashire, have been completed, and work was partially begun there at the commencement of this month.

With regard to the accounts, the depreciation reserve had been increased from £100,000 to £150,000, and the reserve account from £80,000 to £130,000. The profit on the year's working, after making provision for the prior lien debentures and debenture stock, and making the requisite allotments to depreciation and reserve accounts, justified the directors in recommending payment of the full dividend on the preference shares and 5 per cent on the ordinary shares. This was the first time the company had paid a dividend on its ordinary shares since the reconstruction.

The report was unanimously adopted.

## Scotch Ship-Building

Although it is unquestionable that there is a considerable decline in the ship-building trade, yet the orders placed during 1913 will ensure that the depression will not be felt in Scotch yards for some time yet; and at present the Clyde output is quite satisfactory. The total Scotch launchings for January amounted to 19 keels of 30,812 tons, of which 11 ships totalling 22,272 tons were Clyde-built. In January of last year only five vessels with a total of 9,755 tons left the stocks on the Clyde, and although the output for this January does not include any large liners or naval vessels the general average for the month has been maintained.

Two ships launched from Scottish yards early in February are of unusual interest to marine engineers. One, the Mississippi, built by Messrs. Harland and Wolff at their Glasgow yard for the Atlantic Transport Line, is a twin-screw vessel of some 5,000 tons gross, driven by internal combustion engines of the Diesel type made by the Burmeister and Wain Oil Engine Co., of Glasgow, and is the largest ship of the kind hitherto built on the Clyde, although she is the first Messrs. Harland and Wolff have built for internal combustion engines.

The other ship is the Transvaal, of 4,383 tons gross, built by Messrs. Ramage and Ferguson, of Leith, for the East Asiatic Co., of Copenhagen, and is the largest steam vessel yet constructed at Leith.

## Blast Furnace Stoves

BY J. E. JOHNSON, JR.

In the third decade of the nineteenth century James Beaumont Neilson, who from plain beginnings had made for himself a distinguished position as a gas engineer and authority on matters of combustion, was consulted by a furnaceman as to the reason for the very unsatisfactory work of his furnace, particularly in Summer.

This started Neilson on a long investigation. Among other things he experimented with the use of preheated air on gas burners and on blacksmiths' fires and found that the effect was a marked increase in the brilliancy and intensity of the combustion. In 1828 he took out a patent on the use of preheated air in the blast furnace, but even after surrendering two-thirds of his patent to furnace owners he had the greatest difficulty in obtaining a chance to make a trial of the process.

Finally after several years of effort and after overcoming the most factitious and most unreasonable objections to changes in insignificant details such as the shape of the blast pipe he made a demonstration and while the increase in blast temperature was only 80 deg. Fahr. the results were so obvious that the system was at once adopted and higher temperatures obtained.

Then he was at once thrown into another difficulty—that of preventing the overthrow of his patent by a combination of Scotch furnace owners who took a pledge to break his patent virtually "by legal means or otherwise" in order to avoid the payment of his moderate royalty of 1s. per ton, though the saving effected amounted to 32s. per ton.

It is rather a relief to realize that such piracy, which we have been taught to regard as the product of our own times, flourished even in those "good old days."

It is still more pleasant to know that after innumerable trials which went thrice to the House of Lords, Neilson and his associates won, and that on the royalties he finally received he was enabled to pass the closing years of his life in comfort and leisure devoted very largely to what would now be called welfare work. The results obtained were probably very much beyond Neilson's most sanguine expectations, and within a few years the warm blast was used in producing by far the largest proportion of all the iron made. The reason for this saving so disproportionate to the amount of heat introduced by the warm blast will be explained in an article on thermal action of the furnace. We have here only to deal with the apparatus used for heating the air.

The first apparatus used was in all cases a nest of pipes of some sort in a masonry chamber, within which the gas from the furnace burned around the pipes while the blast on its way to the furnace passed through them. In early days these stoves were set on the top of the furnace, or if not immediately on top of it at the level of the top and just to one side, as has briefly been described in connection with boilers, so that the burning gas from the open furnace top could be drawn into them. This had the disadvantage that the cold blast had to be taken to the top of the furnace and the hot blast brought back to the bottom with the loss of heat consequent upon that journey, and as soon as the closed top was introduced the stoves were set at the ground level, with great advantages in first cost and in convenience.

The temperature to which the blast could be heated in these stoves was strictly limited by the fact that the pipes constituting the heating surface were rapidly destroyed if a certain temperature, found by experience, was exceeded by even a small margin, and if the stoves were fired while no blast was passing through them to cool them off, they might be completely destroyed in a period of an hour or two

To meet this condition the late Sir William Whitwell conceived the idea of applying to this service the regenerator previously invented by Sir William Siemens, which consisted of a pair of chambers filled with brick work, through which passed a great number of passage ways arranged to present as much surface as possible.

Through these passage ways of one chamber the hot waste gases of combustion were passed for an interval sufficient to heat the bricks to a high temperature; then the gas was cut off from this and thrown into the second chamber, and the air to support combustion was drawn through the first chamber, from which it absorbed heat by direct contact with the hot surfaces of the bricks. When a sufficient amount of air had passed to lower the temperature of the bricks below that which would impart the required temperature to the air, the gas currents were again reversed in relation to the chambers, the gas being put back through the first one and the air currents being drawn through the second.

For melting the crucible steel, the first purpose to which Sir William Siemens applied his invention, the hot air for combustion was drawn through the checker work under the action of the stack draft, the pressure within the checkers, therefore, differed by only a few inches of water from that of the atmosphere, and masonry construction throughout was sufficient for tightness under this difference of pressure.

In order to apply this system to the blast furnace, however, the chambers had to be so constructed as to withstand the pressure of the air after compression to the pressure required for the blast furnace, because obviously the blowing engines could not handle blast heated to a temperature of 1000 deg. or so. Therefore, the blast must be compressed first, and after heating must go directly to the furnace.

For this reason Sir William Whitwell built his stoves in the form of cylindrical chambers with a top either cylindrical or dome-shaped to prevent deformation under pressure. The bottom was flat because prevented from deforming by the weight of brick work upon it. The shell of these chambers was of iron (later steel) plate, riveted together air-tight and strong enough to resist the maximum blast-pressure expected.

There was also another change in the conditions as compared with those of the steel melting furnace. There the gas to do the heating had already been burned and was simply hot waste gas. The waste gases of the blast furnace, on the other hand, are not particularly hot, but are highly combustible, and in order to provide a gas burner and combustion chamber these fire brick stoves required, therefore, four connections. First an opening for the gas burner, second an opening to the draft stack, third a connection for the cold blast from the blowing engine, fourth a connection for the hot blast to pass to the tuyères of the furnace.

All of these openings were required to be alternately closed air-tight and opened at frequent intervals, and must retain their tightness under conditions of temperature injurious to any metal available for construction. This meant that all metal parts around these openings had very largely to be water-cooled. The brick stove, therefore, brought many annoyances and difficulties of operation in its train, and, while it gives blast temperatures about 50 per cent higher than those permitted with the iron pipe stove, its first cost is greater, and this with the inconveniences and difficulties of operation and maintenance resulting from the conditions described above, retarded its development somewhat, so that a few plants have continued to use the iron pipe stove, but except in charcoal practice they rapidly disappear.

With this general view of the situation we may proceed to describe the two classes of stoves.

### The Iron Pipe Stove

This stove had a development of about a half century before it was cut off by the preponderating advantages of the brick stove, and in this interval a type of construction was evolved which was almost universally used. This consisted of a large brick chamber lined with fire brick, beneath the brick floor of which passed horizontal pipes with nozzles or connections on their top surface, and a vertical partition in their central plane. On these were arranged U-shaped pipes reaching practically to the top of the chamber, through which the air had to pass on its way from the blowing engine to the furnace; short-circuiting of the U-pipes was prevented by the central vertical partition. Around these pipes burned the furnace gas entering at one end and passing through the rows of pipes and through the baffle walls to the other end, where at last it passed out of the stack.

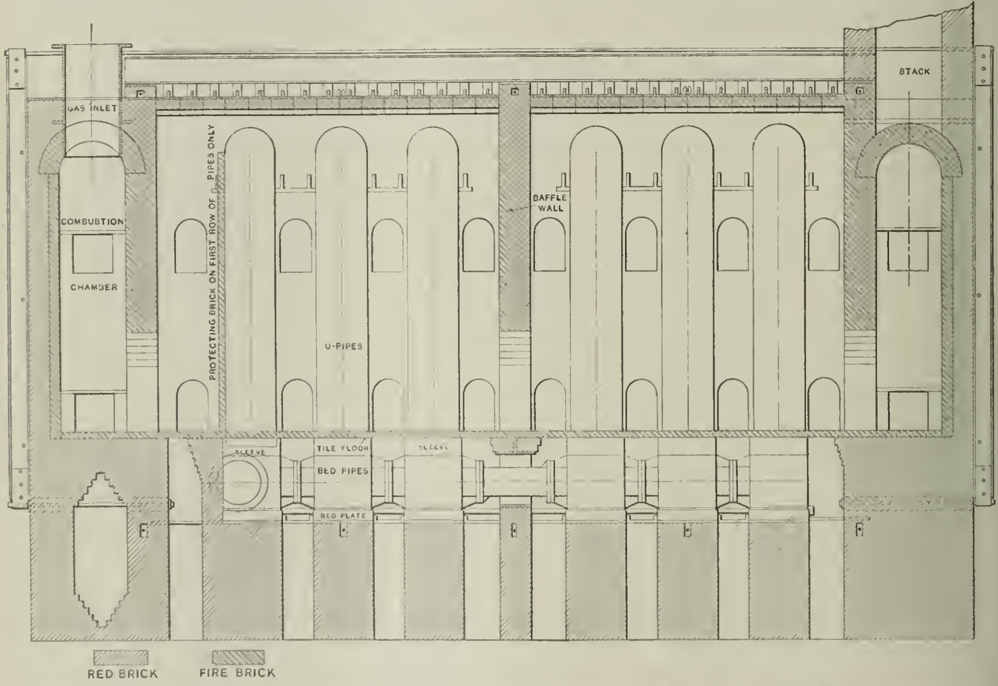


FIG. 1—IRON PIPE STOVE, GLENDON TYPE; LONGITUDINAL SECTION THROUGH CENTER

An excellent design of this type of stove is shown by Figs. 1, 2, 3 and 4, which illustrate a stove built by the Longdale Iron Company at their plant at Longdale, Virginia, under the designs of Mr. H. Firmstone, the president of the company. Fig. 1 is a vertical longitudinal section, Fig. 2 a vertical transverse section, Fig. 3 a sectional plan, Fig. 4 a detail of the U-pipes.

It will be seen that upon a masonry foundation rests a series of cast-iron bed-plates strongly bolted together and planed on their top surfaces. Upon these rest the bed pipes, square in cross section, with a central vertical partition and with three lateral nozzles on each side, in addition to the nozzles for the pipes on top.

None of these bed pipes have any connections on their ends except that the outer chamber of the bed pipe at one end is prolonged into an inlet nozzle, and the outer chamber of the pipe at the opposite end is similarly prolonged into an outlet nozzle. Of course, these end chambers are without the lateral nozzles which connect the chambers to one another. The U-pipes are all of elliptical section in order to get a maximum of heating surface for a given area, and the nozzles on the bed pipes are similarly elliptical in section and of the same size as the end of the U-pipes, these ends being enlarged by a sort of collar cast on them which projects outside the body of the pipe about a half an inch, and which fills the spandrel between the two ellipses to a straight line, this being the shape of the exterior of the nozzles on the bed plates also.

It is perfectly obvious, on account of the central vertical partition in the bed pipes, that there is no passage way for the air except through the U-pipes, and the bed pipes being joined in series, with the U-pipes in parallel, the air passes through an entire set of U-pipes on one bed pipe as a single unit, thence to the next bed pipe, and through all the U-pipes on that simultaneously, and so on.

#### THE JOINTS

The principle of these stoves is obviously very simple, but their construction and maintenance have developed a number of problems. The joints between the U-pipes and the bed pipes are universally sealed with what is known as a rust joint, a mixture of fine iron borings and sal ammoniac made into a stiff paste and caulked into place. This mixture rusts with great rapidity; this converts the whole into an homogeneous mass of iron oxide, which is firmly cemented to the adjacent surfaces of solid metal.

A cast-iron sleeve large enough to go over the nozzles on the bed pipes and the ends of the U-pipes, and about 10 in. in depth, so as to extend 5 in. on each side of the joint when resting on the bed pipe, is slipped over each of these joints and the iron borings run down between it and the surfaces to be sealed. When this is properly done a first-class joint is secured. This is preserved as far as possible from the action of the heat of the direct flame by a floor of flat tile bricks laid between the rows of pipes and resting on the sleeves so as to make a fireproof brick floor above the level of these joints.

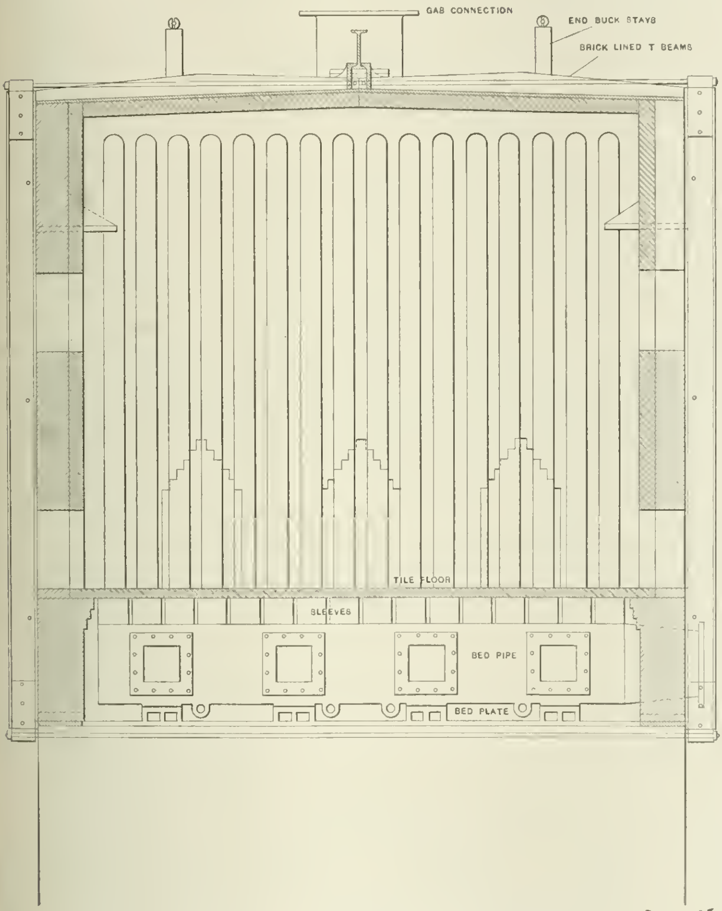


FIG. 2.—IRON PIPE STOVE, GLENDON TYPE; TRANSVERSE SECTION

The U-pipes immediately exposed to the gas coming in from the combustion chamber receive the severest treatment, and these are protected from the direct action of the flame by casting a dove-tail on the side of the pipes placed next to the combustion chamber and sliding over this dove-tail fire brick tiles with a similar dove-tailed slot. These are put on the pipes so as to cover them from top to bottom on the side next to the combustion chamber and greatly increase their life.

### BAFFLE WALLS

In order to prevent the gas from the burners from passing along the top of the stove to the stack without going down around the pipes, baffle walls are built as shown, with openings through their bases through which all the gas has to pass. This forces the gas current to the bottom twice in its course to the stove and secures a good distribution of the flame over the surface of the pipes.

### THE ROOF OF THE STOVE

Many stoves have been built with arched roofs, but these are a great inconvenience when U-pipes have to be taken out and new ones put in, as unfortunately happens not infrequently with this type of stove; and to tear out a portion of this fire-brick arch every time this requires to be done, would add considerably to the expense and delay caused by the operation.

The Longdale stoves were, therefore, covered by long cast-iron T-beams whose lower surfaces were of jaw-shaped or dove-tailed section. These were lined with tiles or shaped fire bricks, the upper part of which fitted into this jaw-shaped section, while the lower part projected out a little beyond the edges of the T-beam. These "shapes" were slid in from the end of the groove and laid in fire clay to make a tight joint and to hold them in place.

In small stoves one end of this T-beam rests on one wall of the oven and the other on the other, but in a large stove, such as that shown here, the span would have been too long for necessary strength, for convenience in handling, and for cheapness in casting the beams, therefore a steel I-beam runs down the center of the oven above the T-beams, and these were cast in two pieces, with the joint in the center, the end at the joint having a hook which rests on the lower flange of the I-beam. This excellent construction gives strength and complete protection of the iron work of the roof from the flame, together with convenience and accessibility. Moreover, this construction makes a level top for the stove, convenient to work upon. This latter is important because when changing pipes shear poles of relatively short and convenient length are set up on top of the ovens resting upon the T-beams, and by this means can be placed exactly where desired, which could not possibly be done with an arched roof. By the use of this construction, where a U-pipe requires to be replaced the half-length T-beams immediately above it can be removed to make room for the operation and then restored to place after it was completed with a minimum of labor and time and without requiring work by masons.

### THE SHAPE OF THE PIPES

The elliptical shape of the pipes is due to a desire to obtain maximum surface for a given area, which may seem at first sight unnecessary, because it might be thought that the area was unobjectionable and that it would be simpler to make the pipes round and not bother about the increased area.

This, however, is open to two objections. First, the length of the bed pipe required for a given number of U-pipes would be greatly increased, which would be objectionable from every point of view, and second, velocity is a matter of much importance in securing proper transfer of heat, much greater transfer being effected at high velocities than at low. Therefore, by constricting the area the velocity of the air passing through the pipes is increased and the temperature obtainable with a given amount of heating surface thereby increased also.

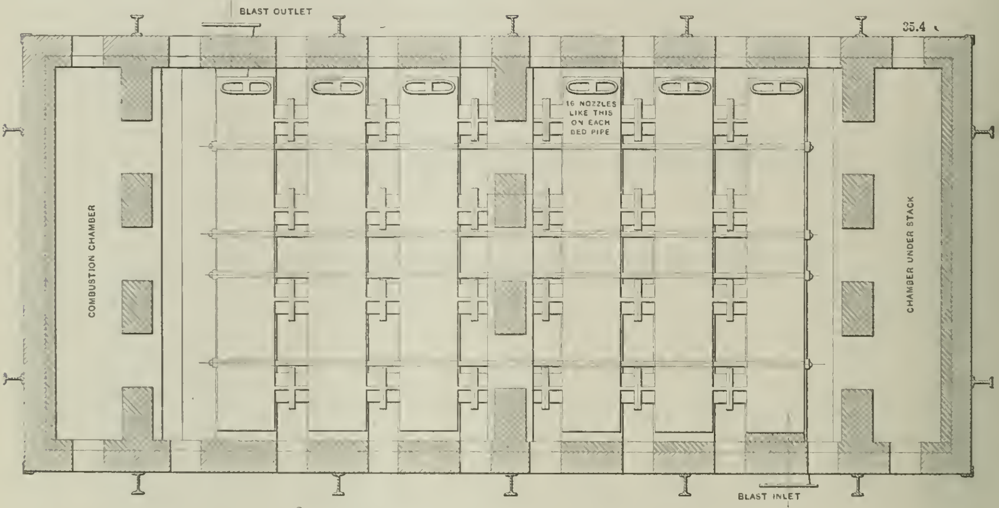


FIG. 3—IRON PIPE STOVE, GLENDON TYPE; SECTIONAL PLAN

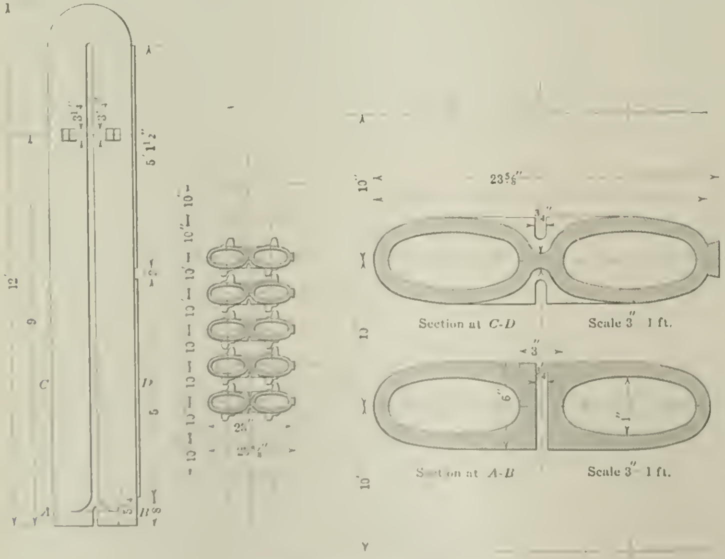


FIG. 4—HEATING PIPES

Many stoves have been built with round pipes, and at the end next to the combustion chamber this is probably wise, because the relatively narrow cross-section of the elliptical pipes makes them bend about much worse under the influence of the flame than do circular pipes whose diameter is equal to the major diameter of the elliptical pipe. But in the rows which are further from the combustion chamber this does not hold to anything like the same extent, and there is probably ample justification for the use of the elliptical section in those rows.

### TWO TYPES OF IRON-PIPE STOVES

Stoves of this general type are divided into two classes, known respectively as the "Glendon" and "Durham," from the former well-known works in the Lehigh Valley, which used and advocated the two types.

There is no essential difference in the construction of these two types, the only difference being in the directions in which the flame and air pass through them. The Glendon stove, as illustrated by the drawings, Figs. 1-4, is on the countercurrent principle. The cold air enters at the draft stack end of the stove and progresses through increasing temperatures to the combustion chamber end, where it is discharged, while in the Durham stove the opposite procedure is followed. This latter at first sight is amazing and contrary to reason, but it appears to be an established fact that higher blast heats can be obtained from stoves of this kind than can be obtained from the Glendon type. The latter type is definitely limited, if it is to give long life and low repair cost, to 850 deg. Fahr., while from 900 to 1000 deg. may be obtained in the Durham type of stove. This is for the reason that when the counter-current principle is used the pipes next to the combustion chamber carry air already heated up almost to the limit of temperature for the stove, and are exposed on the outside to the flame directly from the combustion chamber. They are, therefore, not cooled off or protected on either side, and if very moderate temperatures be exceeded they will fail in one way or another under this combined assault from within and from without.

In the Durham stove, on the other hand, the coldest air passes immediately into the hottest pipes and cools them down to such a degree that they can withstand the external heat. Of course, in this type of stove the waste gases must pass off at a temperature at least 200 or 300 deg. higher than that of the hot blast they are discharging, otherwise the last rows of pipes would be worthless and would absorb no heat, while in the Glendon type of stove the hot gas may be discharged at a temperature several hundred degrees lower than this and still impart heat to the cold blast just entering.

I do not know of a single case in which any investigation has ever been made of the thermal efficiency of iron-pipe stoves, but I am convinced that that of the Glendon type is considerably higher than that of the Durham. On the other hand, if there be no use for the gas saved by this superior stove economy, as was generally the case at plants where these stoves were in service, then it is much better to burn this gas even though the economy of the operation be low, and convert its heat into increased blast temperature which exercises a beneficial effect upon the fuel economy of the plant as a whole.

## Fire-Brick Stoves

The early stoves of this type were of large diameter in comparison with their height, and contained four passes, each passage of the gas vertically through the stove being called a pass. Following the original Whitwell patent a vast number of modifications sprung up and the shape of the stove has undergone an alteration which has now given it a height of four or five times its diameter.

The number of passes has been the subject of experiment, as has almost everything else connected with the stove. It was gradually realized that the fourth pass frequently contributed very little to the heat of the blast, and as every additional pass meant giving up valuable space in the stove for partition walls, with added complexities of brick work at the top and bottom to form safe and durable passageways from one pass to another, the number of passes was reduced to three, to two, and finally to one. Stoves of this type were brought out by Mr. Hugh Kennedy some thirty years ago, which had a single pass straight through from the bottom to short chimneys on the top.

This did away with the necessity of building a chimney, for the stoves had simplified the brick work to the last degree, but the results in practice were unsatisfactory and the stoves did not give the heat desired. They have, therefore, practically passed out of use, and as a result of this and of the gradual disappearance of the four-pass type almost all the stoves built in recent years have been either of the two-pass or the three-pass variety.

## The Three-Pass Central Combustion Chamber Stove

The reason for three-pass stoves is that an odd number of passes brings the gas to be discharged at the top of the stove and by adding a relatively short stack immediately on its top we can obtain the draft necessary without the inconvenience of returning the gas back to the ground level and providing a separate stack for it.

The central combustion chamber is for the reason that, as the average temperature of the brick work is higher around the combustion chamber than elsewhere, it is likely to expand to a greater extent there than anywhere else. When the combustion chamber is in the center this excess expansion takes place along the central axis of the stove with complete symmetry in all directions, while the fact that the annular wall which constitutes the outside of the combustion chamber and presumably attains the highest temperature does not support anything at the top, makes it perfectly free to expand and contract without the destruction of any part of the stove. It is claimed in behalf of the central combustion chamber stove that the side combustion chamber locates this unequal expansion unsymmetrically in the stove with a tendency to greater stresses on one side than on the other.

Moreover, the last pass is very much lower in average temperature than the combustion chamber, and in the McClure stove this relatively cool pass extends all around the outside of the stove and tends to cut down the radiation losses below what they are when the combustion chamber is just within the stove wall on one side.

### THE M'CLURE STOVE

These two ideas underly the design of the McClure stove, which is one of the best-known types of 3-pass stoves, built by the George W. McClure & Sons Co. This is shown in sectional elevation by Fig. 5, the horizontal section at the level of the hot blast outlet is shown in Fig. 6, a horizontal section of the checker work is shown in Fig. 7. It will be seen from Figs. 5 and 6 that gas and combustion air are introduced at the bottom, pass up through the central combustion chamber, down through the first four rings of checker work to the bottom of the stove, where they pass through arches in its intermediate wall, and so up through the exterior row of checkers to the top, where they pass out through the chimney valve and up the stack. The stove is drawn as "on blast," so the chimney valve is shown shut and the arrows are shown in the reverse direction to that described and illustrate the course of the blast as it passes through the stove and finally out the hot blast opening.

It will be seen that the stove contains two domes, one a spherical one resting on the intermediate wall which separates the second and third passes of the gas and one conical one which lines the conical steel dome of the stove structure and prevents its destruction by heat. Fig. 8 shows a perspective view in section of the lower portion of this stove.

The cold blast valve is a flat bell valve rising against a seat bolted into the top of the stove and renewable through the door in the stack in case of necessity. The cold blast elbow directs the air up against the under side of this valve in order to keep it cool and by this means dispenses with water-cooling for it.

Cleaning doors for the space outside the spherical dome are provided just below the top of the cylindrical portion of the stove, while cleaning doors for the portion inside the stove dome are a short distance below these and give access to doorways through the intermediate wall which are bricked up when the stove is in operation but which may be opened to allow passage into the stove for cleaning.

Clean-out doors are also provided at the base of the stove, opposite the arches which furnish communication between the second and third gas passes.

### THE ROBERTS THREE-PASS STOVE

This stove, the design of Messrs. Frank C. Roberts & Co. of Philadelphia, and shown by Figs. 9, 10, 11, 11a and

12, also uses the central combustion chamber principle, but instead of having the second and third passes annular, the space outside the combustion chamber is divided into eight sections by two pairs of parallel walls at right angles to one another whose distance apart is about the same as the diameter of the combustion chamber. This makes four square spaces at the opposite ends of the two principal axes of the stove, and four triangular spaces between these, as shown by Fig. 12.

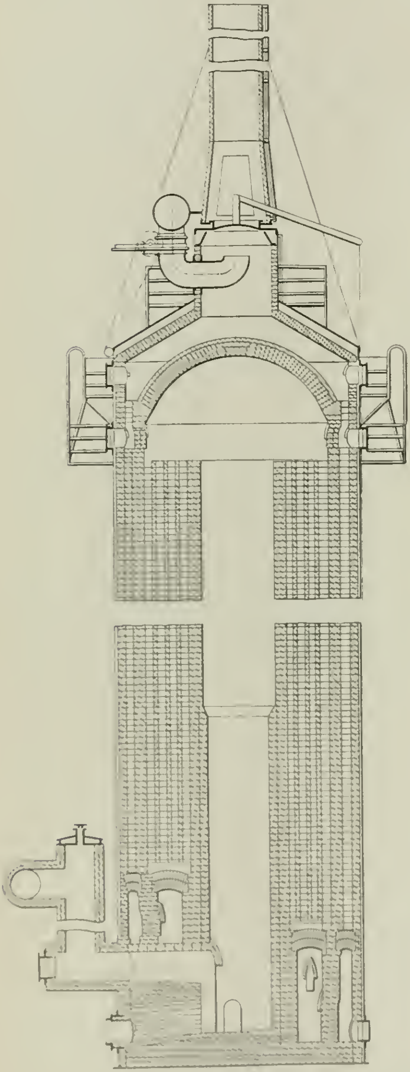


FIG 5

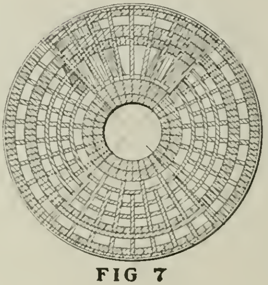


FIG 7

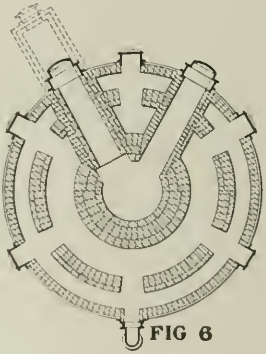


FIG 6

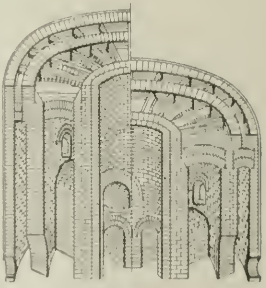


FIG 8

FIGS. 5 TO 8—M'CLURE THREE-PASS STOVE

The intermediate dome of the stove, instead of being a segment of a sphere, is cross-shaped in plan, the tops of the two crosses being arched over with intersecting arches. The gases of combustion pass up through the central combustion chamber, then down through the four square areas within and under this cross-shaped intermediate dome, to the bottom, then up again through the triangular areas, and so to the stack.

The stove, instead of being built of circle bricks and straight bricks laid on the flat, as is the case with the McClure stove, is built up of tiles set on edge and interlocking with one another, as shown by the isometric view, Fig. 12. The checkers are square, instead of having radial ends and circular sides, as in the McClure stove.

This design is used so as to control the gas current to some extent and prevent its traveling too much on one side or another, as it has sometimes been claimed to do in the case of the annular passages of the McClure stove. The cold blast valve and inlet pipe are necessarily located at the top and the current of air is directed against the chimney valve to keep it cooled as in the McClure style.

### Two-Pass Stoves

Commonly two-pass stoves have shared the pre-eminence with three-pass stoves in the best modern practice. In the case of the two-pass stove the valves are all at the ground level, so that any blast leakage has at least a fair chance of being detected by the sound it makes, and the interior construction of the stoves is the simplest possible.

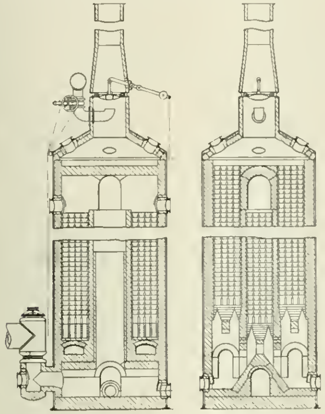
Only a single brick dome is required, and therefore the gas in passing from the combustion chamber to the checkers has only to pass over the top of the combustion chamber wall and down. At the bottom the arrangement of flues for gathering burnt gases from the checker work and leading them to the chimney valve, and distributing the blast from the cold blast valve to the checkers is also extremely simple. Moreover, no space is given up to any intermediate wall of any kind.

### TWO-PASS SIDE COMBUSTION CHAMBER STOVES

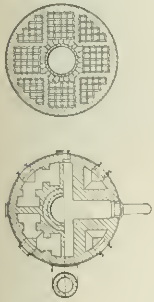
Some operators claim that, while the central-combustion chamber is theoretically correct, in practice the side-combustion chamber type gives little or no trouble if properly constructed, and, owing to the fact that the side-combustion chamber is immediately adjacent to the gas and clean-out openings, it is easier to keep clean than is the central combustion chamber because of the distance of the latter from the operator, and the consequent necessity of removing the accumulation of dirt and slag in the center of the stove at a distance of 8 to 12 ft. from the closest point which the operator can reach. Moreover, the tendency of the blast to wander in the checker work of the two-pass central-combustion type of stove seems to be established beyond question, which is a serious drawback to its efficiency.

The cross-section of the checkers for a stove of this type of a given size is almost twice as great as that of the checkers of the second and third passes in the McClure stove, and this excess area causes a very low velocity through the checkers, so that a very small difference in draft on one side or another will cause a difference in the flow on that side.

The chimney is necessarily at one side in this type of stove and the gas passing through the checkers nearest it has the shortest path to the stock, and for that reason the greatest flow will generally take place on that side, with corresponding inactivity in some other region, whose usefulness is thereby greatly reduced. This is for a reason which must never be forgotten in matters of heat conductivity to or from a fluid, particularly a gas, that high velocity of the fluid absorbing or emitting the heat is of the same order of importance as temperature-difference and surface.



FIGS. 9 AND 10—ROBERTS 3-PASS STOVE



FIGS. 11 AND 12 —ROBERTS 3-PASS STOVE

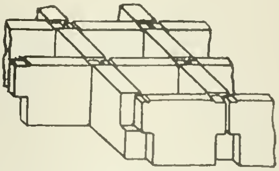


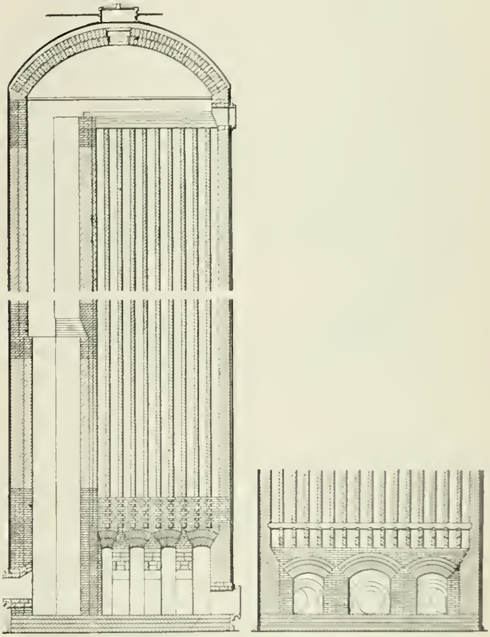
FIG. 11A—ROBERTS 3-PASS STOVE

Efforts have been made to overcome this tendency by equipping each stove with two or even three chimney valves, but while this is undoubtedly good practice, and while two such valves are becoming recognized as correct practice, even for the side combustion stove, it does not, in the experience of some skilled operators, overcome the difficulty completely. Some recent work done in Germany makes it appear possible that we have neglected this question of velocity in the passes far more than its importance warrants and that our stove practice may be materially improved by paying more attention to it.

For these reasons some operators and engineers prefer the two-pass side-combustion chamber stove.

### THE NELSON TWO-PASS STOVE

This stove is built by Arthur G. McKee, contracting engineer, Cleveland, Ohio. The principal claims for the stove are that it secures a very large area of heating surface in proportion to the total cross section of the stove, and that there is a very small percentage of any brick in it, except standard shapes regularly kept in stock by brick manufacturers.



FIGS. 13 AND 14—M'KEE NELSON STOVE

This stove is clearly shown by Figs. 13, 14 and 15. It will be noticed that the back or inside wall of the combustion chamber is given a radius of a curvature the same as that of the front wall. This is a matter of much importance because when this wall has too flat a curvature it becomes a very weak arch and does not resist the thrust due to the expansion of the checker work, and in the past, before experience had taught this costly lesson, many stoves were put out of commission and required to be relined long before they would have been had this point been properly guarded.

The checkers are square in shape and well bonded. and the walls between the flues on which the checkers are built are substantial, so that while these stoves have only been in use for some four or five years, they are well regarded and have given good service.

### ROBERTS TWO-PASS SIDE-COMBUSTION-CHAMBER STOVE

In order to meet the views of those who desired a stove of this type Roberts & Co. also furnish one of the design shown by Figs. 16 and 17. This stove uses exactly the same checkers as the Roberts three-pass stove. It is so completely shown by the drawings that no fuller description is necessary.

### THE TWO-PASS CENTRAL-COMBUSTION-CHAMBER STOVE

Some operators, while admitting the disadvantage of the three-pass construction and preferring the two-pass type, consider the central-combustion chamber the best, and a type of stove designed by Frank C. Roberts & Co. to meet this demand is shown by Figs. 18 and 19.

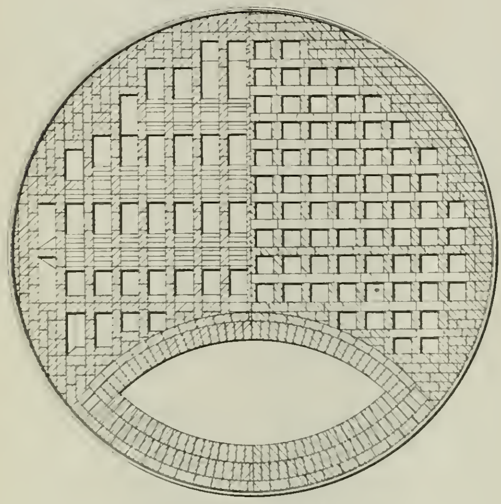
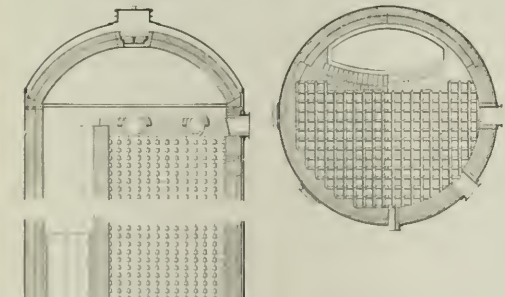


FIG. 15—M'KEE NELSON STOVE

The type of checker work used in these stoves is of the same type as that used in the three-pass stove, except that, instead of being designed for square checkers, it is designed for radial bricks on two sides and circumferential ones on the other sides. This checker work is shown in perspective view by Fig. 19. The construction of the stove is obvious from the drawings and from what has been said of the principles on which it is based. It is provided with the ordinary accessories in the way of cleaning doors, etc.



FIGS. 16 AND 17 ROBERTS TWO-PASS SIDE COMBUSTION STOVE

Mr. Julian Kennedy was one of the first designers of two-pass central-combustion-chamber stoves and used instead of brick checkers hollow key tiles with openings about 9 in. square through the center. The sides of these were radial and the fronts and backs circumferential, so that when stacked up in the stove they made a series of radial checkers of gradually increasing circumferential width passing from the combustion chamber back to the lining of the stove.

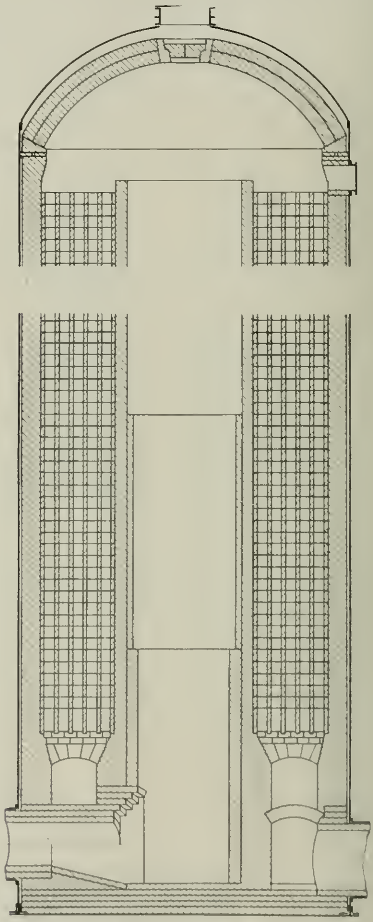


FIG. 18—ROBERTS TWO-PASS CENTER COMBUSTION STOVE

The objection to this construction was that a special shape of hollow tile was needed for each ring of checkers and that the partition wall between each two checker openings being made up by the adjacent sides of two of these hollow tiles was split vertically, therefore its strength was not great, and if one of these gave way it was likely to turn over and obstruct the checker completely. If this happened anywhere in the checker except right at the top it was practically impossible to fix it, and that checker was lost to the stove for the balance of the life of its lining, so such stoves now generally have checkers of brick work built up in the ordinary way.

### Stove Values and Fittings

#### HOT BLAST VALVES

One of the most important details connected with stoves is their hot blast valves. Long experience with these has now developed a type which is in almost universal use on all stoves, subject, of course, to individual variation in the details. This consists of a mushroom or a poppet valve resting on a water-cooled seat, the valve being supported by a water-cooled stem. The design used by the McClure Co. is shown by Figs. 22 and 23.

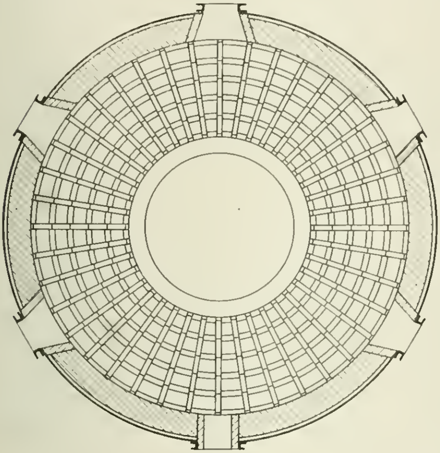


FIG. 19—ROBERTS TWO-PASS CENTER-COMBUSTION STOVE

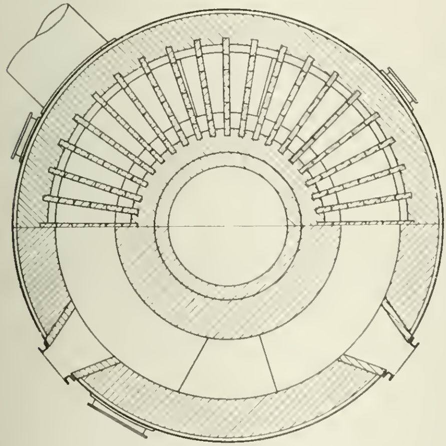


FIG. 20—ROBERTS TWO-PASS CENTER-COMBUSTION STOVE

Commonly the valve is water-cooled as well as the stem, but in the McClure type of hot blast valve this is not done, the valves are made solid without water cooling. The reason for this practice is that if water-cooled valves leak they may discharge a great quantity of water into the hot blast by which it is at once absorbed without showing the least sign, but the effect of this moisture is highly detrimental to the furnace. Moreover, it is claimed by some experienced furnace-men that hot blast valves last about as long without water cooling as they do with it, and that it is better to dispense entirely with the danger of leakage even at the price of a somewhat shorter life of the valves.

The stem, of course, must be water cooled because it must pass through a gland which is required to make a tight joint on it in all positions. This would be quite impossible with the stem heated to redness as it would be if the valve had been for two hours in the closed position. It was formerly the custom to mount the gland immediately on top of the dome-shaped cap of the hot blast valve, but more recently the practice has prevailed of putting in a long sleeve, in the present case about 6 ft. long, which is simply a loose working fit on the valve stem and carries the gland on its top.

The air cooling on the outside of this sleeve prevents the stem from ever getting very warm and the length of the sleeve is such that the portion of the rod which goes inside the hot blast valve proper when it is closed does not come anywhere near the gland when raised into its highest position. This has brought about a great improvement in the conditions of operating and maintaining hot blast valves. It will be seen also that a two-inch air connection is provided at the base of this sleeve whereby additional cooling effect may be secured if desired.

The hot blast valve body is covered with a cast steel cap as shown, and this top is provided with a flange which makes a water box of its upper surface, and the water discharged into this, after cooling the stem, keeps it in good shape. This is, however, protected by an inside cast-steel cover resting on the brick lining of the hot blast pipe. In many cases this cast steel cover is replaced by two large semicircular fire-brick tiles with a hole cut out in their center large enough for the valve stem to pass through, these semicircular tiles resting on the brick work of the lining exactly as shown for the cast cover.

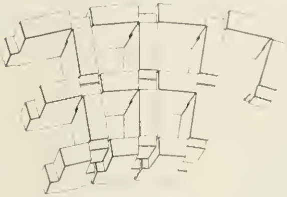
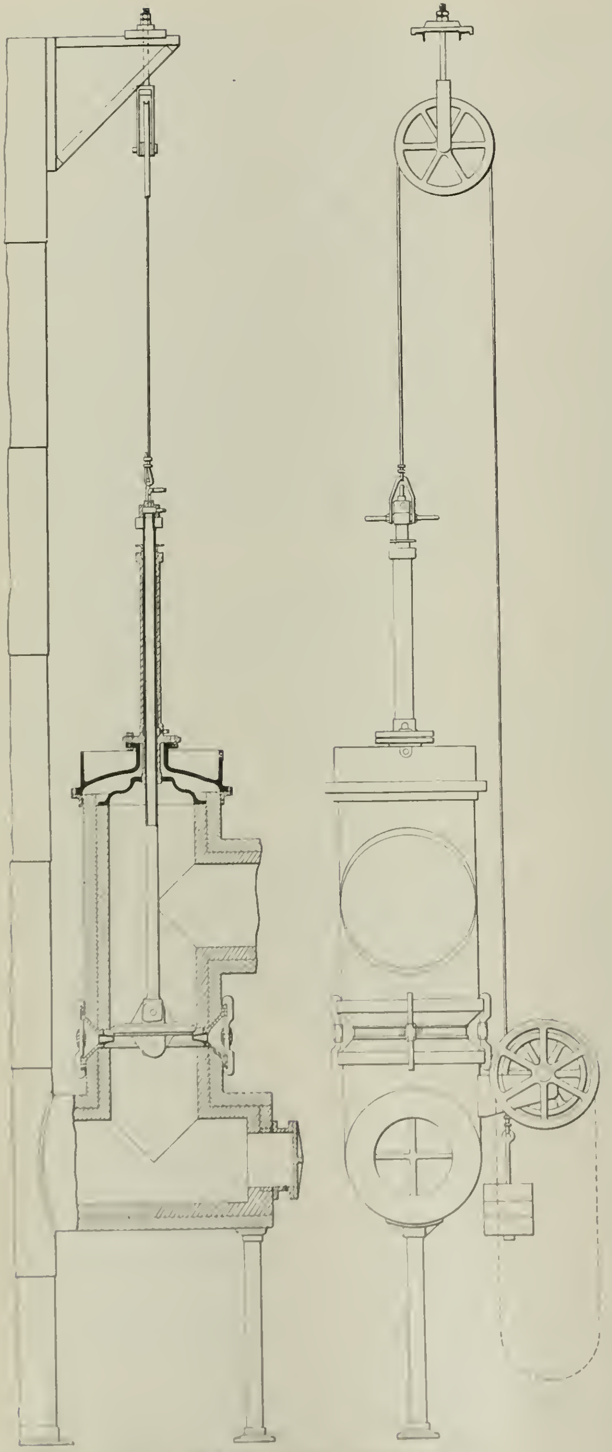


FIG. 21—ISOMETRIC VIEW OF CHECKERS

The water-cooled seat is generally made of bronze, cast hollow to provide for a rapid circulation of water through it. In some cases cast-iron seats with a coil of water pipe cast in them are used, but in good modern practice the bronze seats are becoming almost universal.

It will be seen that the hot-blast valve body is cut entirely in two by this seat and held together by clamp bolts which draw together the top and bottom portions of the valve body so as to make a joint on the top and bottom of the valve seat. This arrangement is used in order to facilitate the changing of these seats, which owing to the high temperature and the abrasive action of flue-dust to which they are exposed are subject to heavy wear and must be renewed quickly, since the blast must be off, and the whole furnace stopped in order to make the change. By slacking off the right and left hand nuts of the clamp bolts and screwing them out until the flat faces on the end of the straight portion of their shanks engage with the flat faces on the seat-rings the latter may be forced apart by an amount slightly greater than the vertical height of the shoulder around the valve seat, and the latter can then be slipped out and a new one quickly inserted. When this is properly centered and the hot blast valve body drawn back to



FIGS. 22 AND 23—M'CLURE HOT BLAST VALVE

place, the projecting ring or shoulder around the seat of the upper flange holds it securely in place.

The hot blast valve is suspended from a rope which passes over a high pulley and back to a drum mounted in bearings bracketed to the side of the hot-blast valve casing. The rope is given two or three wraps around the drum and a counterweight equal to the hot blast valve and stem is attached to the lower end. A hand-wheel on the drum is provided and with this arrangement the stove tender can raise and lower this valve without difficulty. In order to facilitate changing hot blast valves, when this becomes necessary, the high pulley is now, in some cases placed at the top of the stove. This gives ample height to raise the valve, not only to open it, but to lift it clear out of the valve chamber. The high suspension also facilitates swinging the valve to one side in order to lower it to the ground. These are details of much importance when valves have to be changed, since they facilitate doing it quickly. For the same reason the bolts used to bolt the outside cap to the hot blast valve casing should be key bolts, or else the bolt holes should be slotted, so that as soon as the bolt is loosened it may be removed without unscrewing the nut all the way.

### THE COLD BLAST VALVE

A standard design for this valve has gradually been evolved, and while the individual valves used by different stove builders differ in details, the general principle of all is the same. They are all flat slide-valves designed to withstand pressure from one direction only, since this is all that is necessary for this service and are always operated by a handwheel and pinion.

Figs. 24 and 25 show the design of the cold blast valve used by Frank C. Roberts & Co. Its construction and operation are obvious from the drawings. There is one point, however, which might escape the casual observer and is therefore worthy of mention. The rack on which the pinion works to operate the valve is not rigidly attached to the latter, but is free to slide between the guides shown in Fig. 25 within the limits set by the stops which come against these guides and through them move the valve proper. The end of the rack is widened out to a T-shape and this covers a slot through the main valve. When the valve is to be opened to put the stove on blast the unbalanced pressure on it is very great, and if the stove tender succeeded in opening it in spite of the friction produced by this pressure, the rush of air into the stove might be so rapid as to do damage. With the arrangement shown the first movement of the pinion slides the rack proper on the back of the main valve and thus uncovers the port in the latter; through this the air flows until in about a minute the pressure within the stove is the same as that in the blast main; this relieves the friction on the valve, which can then be moved back into the valve housing without further difficulty.

### STOVE BURNERS

Only one type of stove burner is in extensive use, known from its first inventor as the Spearman burner. An excellent design of this by the Wm. B. Pollock Co. of Youngstown is shown by Fig. 33. The gooseneck rests on a slide supported on a hollow base which serves as a gas inlet. When the gooseneck is in the position shown, the opening in its base corresponds with that in the slide and its end projects inside the burner opening in the stove so that the gas enters and burns with the air which is drawn in around the gooseneck and also through the small pipe in the center. The purpose of the latter is to give more intimate mixture of air and gas, thus giving better combustion.

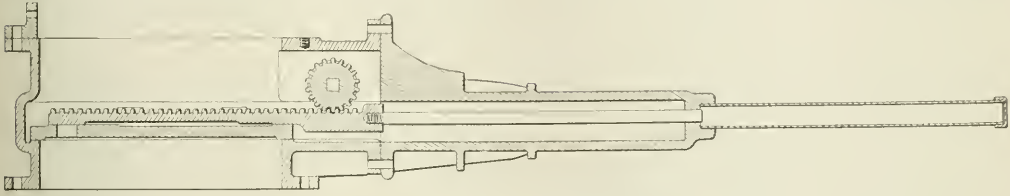


FIG. 24—ROBERTS COLD BLAST VALVE

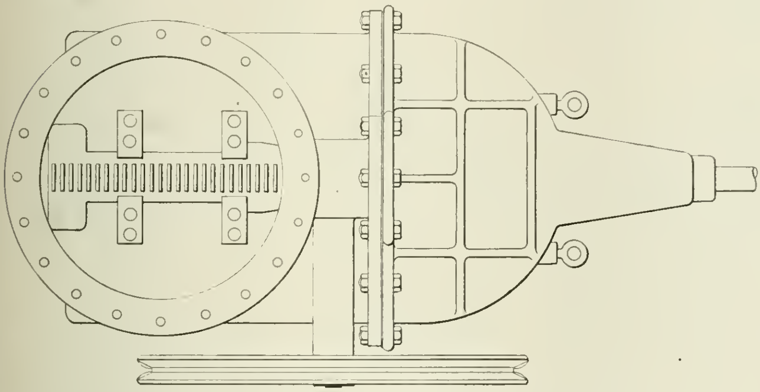


FIG. 25—ROBERTS COLD BLAST VALVE

When the gooseneck is withdrawn its slide closes the opening in the base and the opening in the stove is closed by a cap or door in exactly the same way as the chimney valve opening is closed in the Stenbakken design. (See Fig. 32 on p. 407.)

Much attention is being paid to stove burners at the present time with a view to securing more perfect combustion by better mixture of the air and gas. Mr. A. J. Boynton, superintendent of the Lorain furnaces of the U. S. Steel Corporation, has put in use an excellent burner which is a decided departure from standard practice. The burner consists of a square casting with a round projecting nose which fits close against the seat ring in the burner opening. This casting is mounted on small wheels so that it can easily be withdrawn to permit closing the burner opening in the regular way. The gas enters at the rear and passes through a number of flat passages cored through the casting. The spaces between these passage ways are about the same size as the passages and open at the sides, these multiple side openings being under the control of a slide on each side so operated as to give the same opening at each air port and to vary the amount from nothing to full opening.

The gas is controlled by an independent bell valve in the supply pipe. This gives complete independent control of both air and gas supply and intimate mixture of air and gas at the nose of the burner.

### CHIMNEY VALVES

One of the earliest forms of chimney valves is of the same form as the cold blast valve, but very much larger and water-cooled to withstand the action of the hot chimney gases; its seat is also water-cooled. Such a valve designed by Roberts & Co. is shown by Figs. 26 and 27. Its construction is so clearly shown by the cuts as not to need much description.

Like the hot blast valve this valve is counterweighted and operated by a hand-wheel and drum around which the suspension rope passes. The side furthest removed from the stove is turned to a joint on the face and the pressure of the blast when the stove is on blast holds the valve to its seat. When the stove is blown off it then swings comparatively freely and can be raised by the operator without much difficulty.

A mushroom valve of the same type as that used for hot blast has also been largely used in the past. A type of this valve designed by Frank C. Roberts & Co. is shown by Figs. 28 and 29. This also is water-cooled and operated exactly like the hot blast valve.

Valves of these two types, however, have proven very large and unwieldly and rather troublesome in operation, and there has been a strong tendency in the last few years to develop a type of valve which was more accessible, could be more easily operated, and which did not require water-cooling. One of the first and most successful of these was the Kennedy-Morrison valve shown by Fig. 30. This valve is exactly on the principle of the Spearman burner except that it makes as close a joint as possible against the reinforcing ring around the chimney opening in the stove, so as to prevent the ingress of any outside air to the flue. When the elbow which carries the burnt gas from the stove to the underground flue is withdrawn its slide seals the flue opening exactly as in the Spearman burner, and the opening in the stove is sealed by a cap held to place by one or more screws mounted in swinging yokes, these screws forcing in the ends of a cross-bar or "spider" pivoted to the center of the cap. (See Fig. 31 on p. 407.)

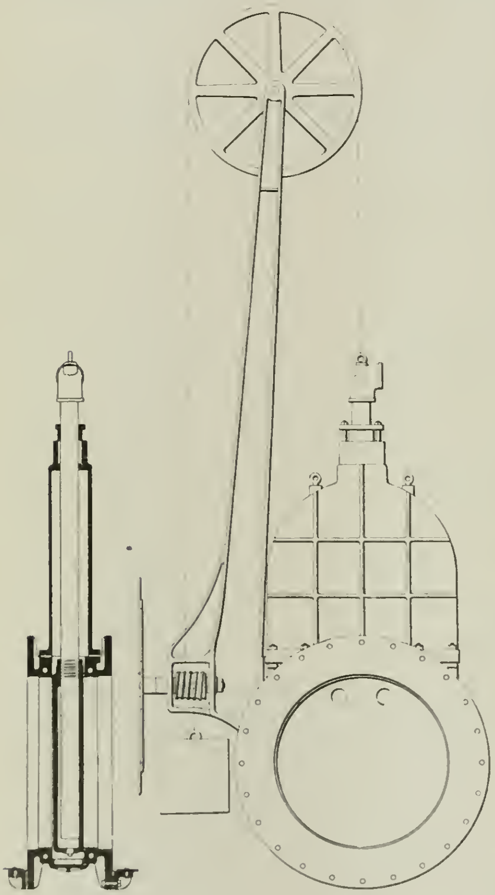


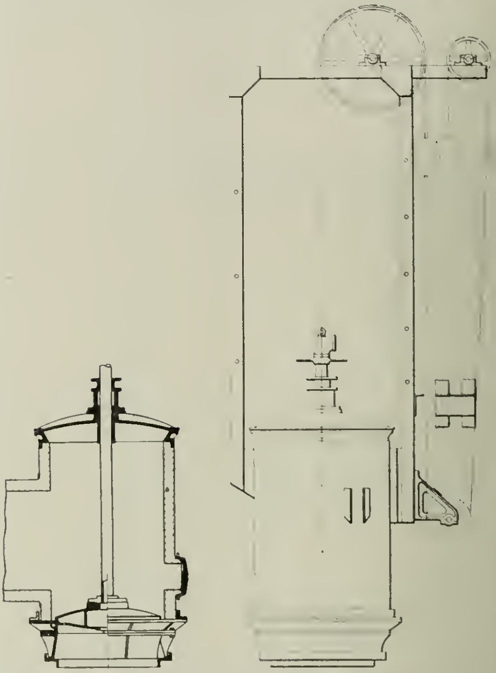
FIG. 27 FIG. 26

ROBERTS SLIDE CHIMNEY VALVE

The Inland Steel Company have in use a modification of this valve designed by their chief engineer, Mr. Ole Stenbakken, in which the goose neck instead of the sliding back and forth rests on a circular seat, the center of the circle being set off from the central plane of the goose neck proper so that when the goose neck is revolved around this base it is withdrawn from the stove, the opening is then closed by a cap as in the Kennedy-Morrison burner. The construction is shown by Figs. 31 and 32. As these goose necks are very large and heavy it is desirable to reduce the amount of movement and effort required to operate them to a minimum and this is admirably accomplished by the rotation of the goose neck around a vertical axis, its opening, when removed from the stove, is closed by a light steel door.

The chimney valves which are used on the three-pass type of stoves have been shown in conjunction with those stoves and do not need further comment here.

BLOW-OFF VALVES



FIGS. 28 AND 29—ROBERTS MUSHROOM CHIMNEY VALVE

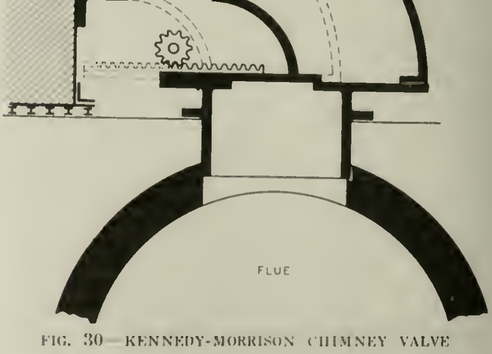


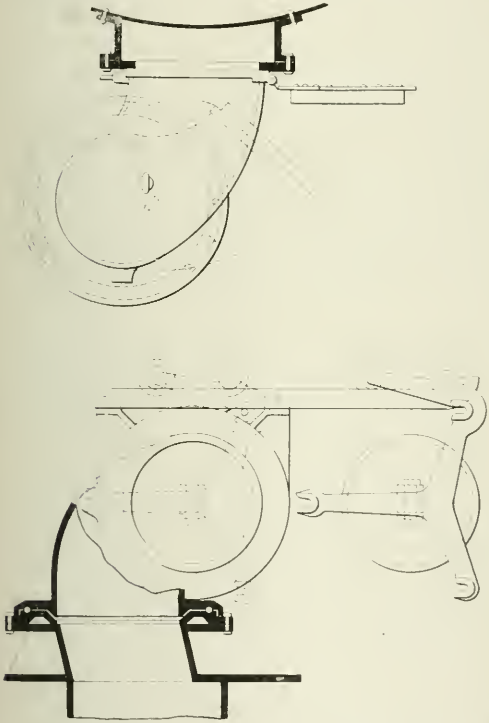
FIG. 30—KENNEDY-MORRISON CHIMNEY VALVE

In addition to the valves above described, there is also an air blow-off valve provided, the function of which is to blow off the air left in the stove when it is taken off the furnace, since, of course, the stove must retain the furnace pressure after its outlet valve is closed. This blow-off valve is placed close to the bottom and is sometimes arranged to open quickly with a lever instead of with a screw, so that as violent a current of air as possible will blow out through it and thereby carry as much dirt as it can from the passages around the base of the stove.

The construction of this valve as used in the McClure stove is shown by Fig. 34. It will be seen that the elbow in which the valve is mounted is arranged to swing as a whole so that this opening serves as a cleaning door as well as a blow-off.

### STOVE CASTINGS

In former times the reinforcing rings around doors, valves, burner openings, etc., were made of cast iron, but the liability of cast iron to crack when subjected to expansion and contraction stresses, and the enormous difficulty of getting at the rivets holding these to place after the stoves are bricked up has brought about the adoption of steel castings for these fittings in all good modern practice. These are somewhat more expensive in first cost, but the failure of a single cast iron fitting after the stove was in operation would involve a loss several times greater than the whole difference in cost between cast iron and steel fittings.



FIGS. 31 AND 32—STENBAKKEN CHIMNEY VALVE

### PACKING

It is almost unnecessary to remark that as the steel shell of the stove is exposed to the air and protected by heavy brick work, it remains comparatively cool while the bricks are heated far beyond the red heat. Therefore, the brickwork expands several times more than the shell.

It is also characteristic of brickwork that while it expands when subjected to heat it tends not to contract to the same amount, and therefore is subject to a small but permanent growth. For this reason the shell of a stove must be considerably larger than the outside diameter of the brickwork, and in order to exert a certain amount of pressure against the bricks and keep them to place this space must be filled with some yielding material. Some constructors prefer to use for this purpose pumice-cinder, others clay, and others again a mixture of these materials.

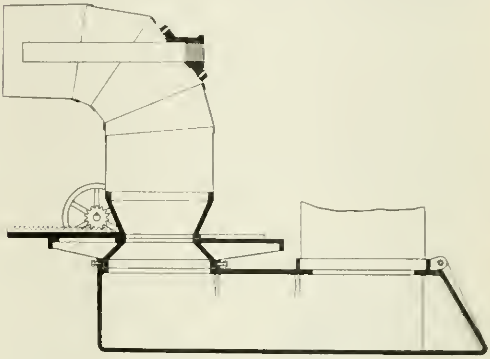


FIG. 33—STOVE BURNER

A similar provision must be made for the vertical expansion of the brickwork and the brick dome of the stove must be left many inches below the shell when the stove is lined. There is not the same necessity for packing material in this space as gravity tends to hold the dome to place, and this space may, therefore, be left open without detriment.

### STACK FOR STOVES

Mechanical draft has never been applied to hot blast stoves so far as I know, their draft always being supplied by a stack.

The three-pass stoves each have their individual stack resting on top of them. In the case of the two-pass stoves the choice of two styles of construction is possible. One is to have a single stack for a battery of three or more stoves, the entire complement of one or two furnaces. The other alternative is to have a single stack for each stove directly connected with it.

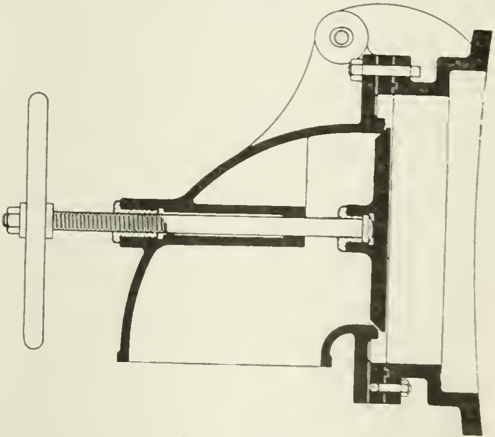


FIG. 34—BLOW-OFF VALVE

The former practice is very much the more general, and in my judgment much to be preferred, since one large stack is undoubtedly cheaper than three or more small ones of the same total capacity. Moreover, if it be desired to cool off one stove for repairs and it be connected only with its own individual stack, no air can be drawn through it after it has cooled off a little, because there is no difference in temperature to produce a draft, although the stove may be far too hot to work in or even to enter. But if all the stoves are connected to a common stack then the chimney valve on the stove which it is desired to cool off may be opened to some extent without seriously impairing the draft of the other stoves and the cold air thus drawn through it will cool it down to a temperature at which it can be entered and repaired in a small fraction of the time in which it would cool to the same extent without this assistance.

### THE DOMES OF STOVES

In the early days many stoves were fitted with a cylindrical top as shown by Fig. 35, and this shape conforms with the mechanical requirement that all sections of the stove shall be circular in order to resist deformation, but this style of top is difficult and expensive to fit and seems particularly liable to give out along the square corners where the horizontal cylindrical surface of the top meets the vertical surface of the stove body, and stoves are now almost universally fitted with either conical or spherical tops.

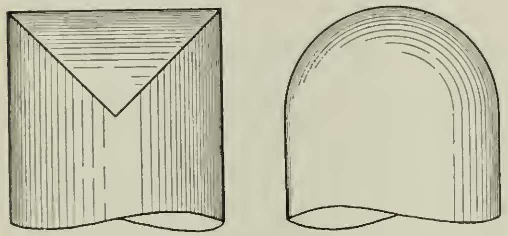


FIG. 35—CYLINDRICAL STOVE TOP

### THE BOTTOM AND BASE RING OF STOVES

The bottom sheet of the stove must of necessity carry all the brickwork in the stove and is, therefore, not capable of repair except by tearing out practically the whole lining of the stove. The principal point of corrosion about stoves appears to be where the cylindrical surface meets the bottom plate, and owing to this corrosion old stoves are liable to fail at this point sooner than almost any other, the base ring contains nearly all the openings made into the stove for cleaning out doors, valves, etc., and its strength is thereby greatly reduced. For these reasons the bottom section should be made of heavier material than the rest of the stove.

The stove base instead of being set down flat on a masonry foundation, as formerly, now generally rests on a set of T-rails placed close together, this carries it up off the ground and prevents corrosion to a large extent.

The joint where the bottom sheet meets the side sheets should always be made with the utmost care and almost without regard to expense. It is very doubtful if flanging is a good construction at this point. A heavy angle bent to the circle and riveted to the bottom and side sheets furnishes a better construction.

### THE CHECKERS IN STOVES

It has been the practice to make checkers in stoves about nine inches square in the past, but this practice is now beginning to undergo a change which is likely to be very rapid, for the reason that until quite recently gas cleaning was not practised to any considerable extent in this country, while the blast furnace gas produced here probably carries more dirt and fine ore than that of any other country, because of the predominant portion of fine sandy ore used.

This dust is carried into the stove by the gas and deposits on the brickwork which, of course, is composed largely of silica; under the intense heat to which this brickwork is exposed the iron ore constituting the larger portion of the flue dirt is fused to the brickwork and the wall of the combustion chamber soon becomes glazed over and finally is slagged away by this action, so much so that a false wall is always built in the combustion chamber, so that this wall may be renewed when it is burnt out without affecting the stove as a whole. In one plant, formerly under my management, we never counted that these walls would last over eight or nine months without repair, and this was due almost entirely to the slagging action of the iron ore carried by the gas.

In the checkers the conditions are not quite so bad, because the temperatures are much lower, but vast quantities of dirt settle on these in light flocculent masses, about the best non-conductor of heat which could be found for such high temperatures. These flocculent masses greatly reduce the flow of gas through the stove and seriously impede the passage of blast through it also. Therefore, it is now necessary at intervals to take each stove off the furnace for several days, cool it down so that it can be entered, put men in the upper dome and clean these checkers by dropping through them weights suspended from a rope or chain. This is a highly laborious performance, and from the nature of the case more or less ineffective. In order to carry out this operation at all, it is necessary to lose the use of the stove for from one to two weeks under the best conditions, and during that time, unless the furnace is more than usually well provided with stove capacity, the blast is improperly heated, and the fuel economy of the furnace suffers.

In recent years it has been found that with the exercise of a certain amount of care the gas can be scrubbed practically free of these impurities at comparatively small expense. This eliminates the necessity of allowing for a coating of flue dust from one to three inches thick on all sides of the checkers. When this is done it becomes a simple matter to use checkers six inches square which are not only as good as, but much better than checkers nine inches square when dirty gas is used.

It is obvious that the amount of heating surface which can be put into a given stove with six-inch checkers is far greater than that which can be put into it with nine-inch checkers and this means that the stove capacity needed to supply a given amount of heat to the blast may be more cheaply obtained, not only in operating cost but also in first cost by putting in a gas-washing plant to supply clean gas, and using somewhat smaller stoves with smaller checkers. The smaller stoves so designed contain more heating surface and maintain a higher efficiency than the larger stoves under the old conditions with dirty gas.

### The Number of Stoves Per Furnace

There is no theoretical reason why one iron-pipe stove should not be sufficient for a furnace, because it is an apparatus which works continuously by the conduction of heat through metal walls exactly as a boiler does. Barring repairs it could run on indefinitely, and small furnaces in the early days were frequently run with only one stove.

As a matter of fact, especially at large furnaces, the number of stoves is increased for two reasons: First, it is difficult to build a single unit large enough to heat the quantity of blast required for a large or even a moderate-size furnace, and at the same time to design it so as to give good control of the heat in all parts. Second, after a certain point is passed it costs no more to build the required stove capacity in two or three units than it does in one, while if there be, say, three stoves on a furnace, then, when one of them requires repairs the other two are still able to heat the blast to a very valuable extent; whereas, if only one stove be provided, when this goes down for repair the furnace must shut down because it is commercially impossible to run a furnace on cold blast.

For these reasons two or three iron-pipe stoves are commonly provided per furnace when that type is used.

In regard to the capacity and efficiency of these, little or nothing is known. As a matter of experience it can be stated that the stove illustrated in Figs. 1, 4 is capable of heating six or eight thousand feet of blast per minute up to 850° F. without such overcrowding as will destroy it too rapidly. In regard to economy and efficiency we have not even the guide of general experience to help us, because there is no way to get at the quantity of gas consumed by one of these stoves without careful experiments on gas flow, etc., which, as far as I know, have never been conducted.

It may be safely stated that the efficiency of the Durham type of stove, that is the parallel-current type, is quite low, because the chimney gases must be discharged at a temperature of twelve hundred or more, and even with theoretically perfect combustion this involves a loss of over 50 per cent. of the heating value of the gas.

Turning now to the fire-brick stove, the conditions are entirely different from what they are in the case of the iron-pipe stove, since it is impossible to get along with less than two of these, one of which is being heated up while the other is giving up its heat to the blast. Furnaces were originally operated with only two stoves of this type, but this condition has long since passed away. Less than three are never contemplated, four is only ordinary good practice, and five have been installed with extremely satisfactory results at some plants.

The reason for the increased number of stoves is twofold. First, to have one in reserve, or at least be in a position to spare one for repairs without crippling the plant; second, because the heating of the blast by this process is an intermittent operation, and therefore the temperature of the blast fluctuates with the condition of the stove. When the stove is first put on it has been heated up to a high temperature, which falls as it gives up its heat and the blast temperature is therefore constantly falling.

When only two stoves are provided these variations are so great as to cause serious irregularities in the work of the furnace. By adding a third stove and burning the gas so as to give them what steel men know as a "soaking heat," their temperature falls much less rapidly while they are on blast. The fact that the relative time on gas is doubled while the time on blast remains the same contributes much to this result. This greatly reduces the irregularities due to the intermittent action of the apparatus.

But, when one stove requires to be taken out of service for repair the furnace is then thrown back onto the two-stove condition. This cuts down the heating surface to two-thirds and reduces the average blast temperature materially as well as making serious irregularities in the temperature curve. Therefore, in order always to have the benefits of three stoves four must be provided; this gives three hours on gas for one on blast, which is a step better than the condition existing when three stoves are used.

Four stoves introduce the possibility of operating along a somewhat different plan, with the object of eliminating inequalities of blast temperature still more. This plan is to blow through two stoves simultaneously, leaving them each on blast one hour, but changing them at alternate half hours. This reduces the time of the stove on gas to one-half the total time, but halves the amount of heat taken out of it at any period. It involves somewhat more work for the stove tender, but practically halves the variations of blast temperature from maximum to minimum.

Here, again, we come to the necessity of occasional repairs necessitating a return to three-stove conditions, and this has caused many operators to consider five stoves a good investment, because then four stoves can always be maintained in operation, even when one is being repaired, and when all five are available each one can be left on gas for three hours and on blast for two hours, with still better results in eliminating irregularities in the blast temperature and maintaining a high average temperature without driving the stove too hard when it is on gas.

It will be seen, then, that the number of firebrick stoves to be supplied per furnace depends to some extent upon natural conditions, which we cannot control, and that if the best results are to be attained under present conditions, not less than four must be supplied. But, since the introduction of clean gas at some plants, it has been found that the stoves do not need to come off during an entire blast for either cleaning or repair, and this fact in addition to the increased economy and greater heating surface attainable as a result of clean gas have a tendency to reduce the number of stoves required, and it may well be doubted if five stoves will in future be installed at plants originally designed to use clean gas. It may be that the number required will fall to three.

### EQUALIZING THE BLAST TEMPERATURE

The proposal has been made by several blast-furnace engineers and operators to apply an equalizer to remove the objectionable peaks from the charts of blast temperature, and several of these apparatus have been built. One of the few in this country was that built by John S. Kennedy and the late John M. Hartmann at the Musconetcong furnace, Stanhope, N. J., which has been most successful in operation.

This apparatus is practically a small stove without combustion chamber or valves filled with very small checker work through which the blast passes on its way from the stoves to the furnace. When the blast is very hot from putting on a fresh stove the excess heat above the average is given up to the checker work in which it remains stored until the temperature of the blast falls below the average, owing to the cooling of the stove, when this stored surplus flows out and makes up the deficiency.

Mr. Kennedy has told me that this apparatus smoothed down the "saw teeth" on the blast temperature charts so that the maximum temperature difference for long periods continuously was less than twenty-five degrees. Without such an apparatus the drop in temperature between putting on and taking off a stove will run from 50 to 150°, depending on the number of stoves and how they are handled.

Another method for obtaining a uniform blast temperature is by the use of a cold-wind mixing valve. This valve is located on the hot blast main into which it opens and is connected with a branch from the cold blast main. By opening this valve cold blast directly from the engine can be admitted into the hot blast main, thus cutting down the temperature of the blast by admitting a considerable quantity of this cold air as a fresh stove is put on the furnace and gradually diminishing this quantity down to nothing, at or near the time when the stove comes off.

By this means the blast temperature may be maintained uniform, but this method is open to two objections: First, that the uniform blast temperature is, in that case, the lowest temperature furnished by the stoves instead of the average, and, second, the equalization depends wholly on the skill and fidelity of the stove tender, and if done properly requires such frequent attention by him as militates against his assisting at other work.

Attempts have been made to provide an automatic control of this valve, which would relieve the stove tender of the duty of regulating it and would give perfect equalization of the blast temperature, but so far as known to me none of the apparatus designed for this purpose are now in regular commercial use.

### The Size and Heating Surface of Stoves

Practice in regard to these matters in the past has been based on general experience and the belief of the furnace man or engineer that stoves of about such a size would be sufficient to supply the hot blast for a given furnace. It is not a rule, but it seems to be according to general practice that the diameter of the stove shall be about the same as the bosh diameter of the furnace, and that its height shall be as a minimum that of the furnace and from that up to twenty or twenty-five per cent. more.

Until recently but little attention was paid to the quantity of heating surface furnished per foot of stove height, but there is evidence that this condition is passing and that within a few years stoves will be bought on their heating surface, practically as boilers are today. This has been impossible except in the most general way in American practice until now, because the hard driving of American furnaces, combined with the enormous percentage of extremely fine ore used at seventy-five per cent of them, has made an exceedingly dirty gas, and this dirt depositing on the checkers in the way already described has reduced the efficiency of the stove in proportion to the extent in which it has been allowed to accumulate, so that stoves kept clean and under good management at one plant are capable of heating a given quantity of blast to a much higher temperature than similar stoves at another plant where they are not properly cleaned.

To a large extent these conditions have been past control and absolutely past all calculation. General experience has, therefore, been practically the only guide. With the introduction of primary cleaning for all the gas, that which goes to the stoves will be in vastly better condition than it is now, the stoves will stay clean for far longer periods and will have not only a higher but a more definite efficiency.

The advantages of smaller checkers already pointed out, which become available under those conditions, will cause competition among stove builders to give the maximum amount of heating surface per stove, and we shall gradually reach the place where the capacity and economy of stoves are as well understood as that of any other apparatus around the place, a condition which certainly does not exist at the present time.

There has been in recent English and American literature little or nothing on the hot blast stove from the operating point of view, but in December, 1912, Mr. A. N. Diehl published before the Engineers' Society of Western Pennsylvania a very valuable paper giving the results of long and careful investigation of the subject, and in October, 1913, in a discussion of the sub-

TABLE NO. 1.
EXCERPT FROM STOVE TESTS.

| Stove. | Heating surface sq. ft. | Volume of brickwork cu. ft. | Fuel gas. | Volume of fuel gas per Min. | Calorific value of fuel gas B.T.U. | Blast per Min. cu. ft. | Temperature flue gas. Max. | Min. | Avg. | Temperature blast. Max. | Min. | Avg. | Heat balance. Percent Absorbed blast. | Lost in flue gas | Stove on gas. Mins. | Stove on blast Mins. | Flue gas percent CO | O₂ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Center Comb. 3-Pass | 49865 | 20831 | Clean | 4282 | 108.5 | 36328 | 680 | 370 | 630 | 1555 | 1270 | 1418 | 63.37 | 17.63 | 172 | 58 | 0.47 | 2.29 |
| 2 | | | | 4527 | 105.8 | 35742 | 720 | 566 | 670 | 1600 | 1360 | 1462 | 62.24 | 17.40 | 179 | 60 | 0.12 | 1.18 |
| 3 | | | | 3847 | 99.0 | 36542 | 650 | 540 | 619 | 1440 | 1235 | 1328 | 61.59 | 17.55 | 180 | 60 | 2.40 | |
| 4 | | | | 3386 | 104.4 | 36109 | 640 | 540 | 614 | 1335 | 1136 | 1231 | 66.02 | 16.87 | 181 | 59 | 0.11 | 2.94 |
| Average. | | | | 4010 | 104.4 | 36130 | 685 | 554 | 633 | 1487 | 1250 | 1359 | 63.30 | 17.34 | 178 | 59 | 0:77 | 1.65 |
| 1 Center Comb. 2-Pass | 39220 | 17974 | Clean | 3838 | 104.3 | 40030 | 476 | 370 | 442 | 1310 | 800 | 957 | 61.75 | 24.54 | 175 | 58 | 0.60 | 6.00 |
| 2 | | | | 3523 | 94.1 | 33905 | 670 | 495 | 626 | 1440 | 1035 | 1200 | 53.28 | 28.70 | 171 | 52 | 0.60 | 6.50 |
| 3 | | | | 3497 | 102.1 | 37678 | 700 | 490 | 615 | 1200 | 850 | 1051 | 44.03 | 34.17 | 179 | 50 | 0.80 | 9.70 |
| 4 | | | | 3548 | 104.5 | 38590 | 650 | 500 | 624 | 1340 | 1035 | 1156 | 61.24 | 20.14 | 172 | 61 | 0.90 | 4.60 |
| 5 | | | | 3489 | 94.3 | 40580 | 525 | 420 | 441 | 1451 | 1036 | 1201 | 64.48 | 19.28 | 199 | 64 | 0.80 | 2.90 |
| 6 | | | | 2805 | 99.7 | 34343 | 680 | 485 | 612 | 1310 | 970 | 1076 | 66.73 | 13.16 | 181 | 60 | 1.10 | 2.50 |
| 7 | | | | 3156 | 96.6 | 39632 | 535 | 430 | 489 | 1340 | 1010 | 1162 | 65.26 | 12.33 | 190 | 57 | 2.00 | |
| 8 | | | | 3092 | 99.2 | 38852 | 525 | 420 | 476 | 1470 | 1030 | 1149 | 61.98 | | 182 | 57 | 3.30 | |
| Average. | | | | 3368 | 99.3 | 37951 | 695 | 451 | 540 | 1358 | 969 | 1094 | 58.60 | 20.40 | 181 | 57 | 1.26 | 4.27 |
| 1 Center Comb. 2-Pass | 39220 | 17974 | Dirty | 4120 | 103.2 | 39149 | 860 | 610 | 788 | 1450 | 1015 | 1163 | 47.13 | 29.50 | 200 | 66 | 0.80 | 5.60 |
| 2 | | | | 4735 | 94.9 | 39000 | 915 | 650 | 819 | 1460 | 1000 | 1203 | 54.20 | 24.76 | 190 | 66 | 0.80 | 0.60 |
| 3 | | | | 4241 | 105.0 | 38735 | 960 | 620 | 864 | 1410 | 990 | 1179 | 50.68 | 24.20 | 169 | 51 | 0.80 | 1.00 |
| 4 | | | | 3898 | 99.4 | 38780 | 930 | 600 | 813 | 1425 | 1000 | 1148 | 66.97 | 24.95 | 149 | 51 | 0.60 | |
| Average. | | | | 4248 | 100.6 | 38916 | 916 | 620 | 821 | 1336 | 1001 | 1176 | 54.24 | 25.85 | 177 | 59 | 0.75 | 1.80 |
| 1 Side Comb. 2-Pass | 30725 | 7494 | Dirty | 2832 | 79.6 | 35802 | 510 | 340 | 457 | | | 1047 | 42.30 | | 179 | 30 | 0.82 | 4.47 |
| 2 | | | | 3114 | 84.1 | 35802 | 550 | 296 | 475 | | | 982 | 59.3 | | 174 | 53 | 0.24 | 1.56 |
| 3 | | | | 3061 | 82.6 | 36022 | 430 | 320 | 377 | | | 844 | 57.80 | | 157 | 45 | | |
| 4 | 21854 | 5330 | | 2448 | 83.1 | 35802 | 730 | 305 | 567 | | | 974 | 84.90 | | 196 | 49 | 0.26 | 2.64 |
| 5 | | | | 2772 | 75.8 | 35802 | 540 | 390 | 478 | | | 891 | 62.30 | | 173 | 51 | | |
| 6 | 32632 | 6204 | | 3524 | 83.2 | 36400 | 655 | 495 | 600 | | | 986 | 56.10 | | 180 | 54 | | 3.58 |
| 7 | | | | 3887 | 87.9 | 36400 | 690 | 450 | 606 | | | 890 | 58.20 | | 165 | 60 | 0.17 | 1.77 |
| Average. | | | | 3091 | 82.7 | 35990 | 583 | 370 | 609 | | | 977 | 57.30 | | 175 | 49 | 0.21 | 1.98 |

Note Side Combustion Stove as above, volume of brickwork is for checkers only
Center Combustion Stoves, Duquesne
Side Combustion Stoves, Foreign

TABLE NO. 2.

SHOWING HEAT LOSSES IN STOVE PRACTICE DUE TO INEFFICIENT COMBUSTION OF FUEL GAS.

| Test No. | Volume of fuel gas per Min. cu. ft. 1 | Volumetric ratio flue gas to fuel gas. 2 | Volume of flue gas per Min. cu. ft. 3 | Calorific value of fuel gas B.T.U. 4 | Average tempt. flue gas. 5 | Flue gas. Percent CO 6 | Flue gas. Percent $O_2$ 7 | Heat losses in flue gas due to CO 8 | Heat losses in flue gas due to $O_2$ 9 | Volume of CO in flue gas per Min. cu. ft. 10 | Volume of excess air in flue gas cu. ft. 11* | Total heat losses due to CO & excess air. Percent 12 | Coke eqv of heat losses, per Hour. Lb 13† | Coke eqv of heat losses per day per Fce Lb. 14‡ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4282 | 1.993 | 8534 | 108.5 | 630 | 0.47 | 2.29 | 2.46 | 2.15 | 30.11 | 862.51 | 4 61 | 105.2 | 7582 |
| 2 | 4527 | 1.718 | 7777 | 105.8 | 870 | 0.12 | 1.18 | 0.53 | 1.07 | 9.33 | 416.21 | 1.60 | 27.7 | 2714 |
| 3 | 3847 | 1.540 | 5324 | 99.0 | 813 | 2.40 |  | 11.61 |  | 142.18 |  | 11.61 | 217.5 | 15640 |
| 4 | 3386 | 1.849 | 6260 | 104.4 | 614 | 0.11 | 2.94 | 0.50 | 2.70 | 6.89 | 849.91 | 3.20 | 55.5 | 1996 |
| Average | 4010 | 1.775 | 7049 | 104.4 | 633 | 0.77 | 1.85 | 3.77 | 1.37 | 47.12 | 709.57 | 5.24 | 104.0 | 7762 |
| 1 | 3838 | 2.928 | 11238 | 104.3 | 442 | 0.60 | 8.00 | 4.70 | 5.31 | 67.43 | 4136.25 | 13.01 | 256.1 | 18439 |
| 2 | 3623 | 2.000 | 7363 | 94.1 | 625 | 0.60 | 6.50 | 5.15 | 7.53 | 44.18 | 2182.09 | 12.58 | 207.3 | 14925 |
| 3 | 3497 | 2.574 | 9001 | 102.1 | 615 | 0.80 | 9.70 | 8.31 | 12.72 | 72.00 | 3938.68 | 21.03 | 369.1 | 26576 |
| 4 | 3546 | 2.078 | 7373 | 104.5 | 624 | 0.90 | 4.60 | 6.37 | 4.64 | 68.36 | 1461.72 | 9.91 | 221.7 | 15962 |
| 5 | 3489 | 1.757 | 6130 | 94.3 | 812 | 0.80 | 2.90 | 4.62 | 2.60 | 38.78 | 761.72 | 7.12 | 115.2 | 8294 |
| 6 | 2805 | 1.806 | 5063 | 99.7 | 441 | 1.10 | 2.50 | 8.22 | 1.24 | 55.69 | 471.92 | 7.36 | 110.2 | 7924 |
| 7 | 3166 | 1.281 | 4043 | 96.6 | 489 | 2.00 |  | 9.39 |  | 80.88 |  | 9.39 | 140.8 | 10137 |
| 8 | 3092 | 1.558 | 4817 | 99.2 | 476 | 3.30 |  | 14.34 |  | 158.96 |  | 14.34 | 216.6 | 15595 |
| Average | 3368 | 2.134 | 6853 | 99.3 | 540 | 1.28 | 4.27 | 7.12 | 4.62 | 71.63 | 1626.54 | 11.87 | 204.6 | 14733 |
| 1 | 4120 | 2.415 | 9950 | 103.2 | 788 | 0.80 | 6.60 | 6.32 | 8.48 | 79.60 | 2473 38 | 13.80 | 288.5 | 20772 |
| 2 | 4735 | 1.884 | 8731 | 94.9 | 819 | 0.80 | 0.60 | 4.11 | 0.28 | 69.85 | 83.74 | 4.39 | 97.0 | 6984 |
| 3 | 4241 | 1.731 | 7341 | 105.0 | 864 | 0.80 | 1.00 | 3.75 | 0.60 | 58.73 | 210.62 | 4.55 | 100.0 | 7200 |
| 4 | 3598 | 1.654 | 5447 | 99.4 | 813 | 0.60 |  | 2.86 |  | 32.68 |  | 2.85 | 54.2 | 2892 |
| Average | 4248 | 1.911 | 7867 | 100.6 | 821 | 0.75 | 1.80 | 4.01 | 2.39 | 60.21 | 691.95 | 6.40 | 134.9 | 9712 |
| 1 | 2832 | 1.834 | 5194 | 79.6 | 457 | 0.82 | 4.47 | 8.23 | 3.71 | 42.59 | 1008.16 | 9.94 | 110.4 | 7935 |
| 2 | 3114 | 1.546 | 4814 | 84. | 475 | 0.24 | 1.56 | 1.45 | 1.09 | 11.55 | 330.72 | 2.54 | 32.8 | 2362 |
| 3 | 3061 |  |  | 82.6 | 377 |  |  |  |  |  |  |  |  |  |
| 4 | 2448 | 1.718 | 4205 | 83.1 | 569 | 0.26 | 2.64 | 2 08 | 2.92 | 10.93 | 484.42 | 5.00 | 42.6 | 3067 |
| 6 | 2772 |  |  | 75.8 | 478 |  |  |  |  |  |  |  |  |  |
| 6 | 3624 | 1.778 | 6266 | 83.2 | 600 |  | 3.58 |  | 3.16 |  | 1072.12 | 3.16 | 58.0 | 4176 |
| 7 | 3887 | 1.674 | 6118 | 87.9 | 606 | 0.17 | 1.77 | 1.01 | 1.66 | 10.40 | 491.28 | 2.61 | 43.7 | 3146 |
| Average | 3091 | 1.690 | 5319 | 82.7 | 509 | 0.21 | 1.99 | 2.15 | 2.49 | 15.07 | 757.44 | 4.66 | 57.5 | 4137 |

*Col. No. 11—Over and above that required to oxidize the CO present in the flue gas.
†Col. No. 13—Per stove per hour and based on coke having a calorific value of 12 200 B. T. U. per lb. as received.
‡Col. No 14—Based on four stoves per furnace, or 72 stove hours per day on gas and 24 stove hours per day on blast.
Note: All gas volumes and calorific values are at Standard Conditions, 62 F. and 30 in. Hg.
Above test Numbers correspond to those given in Table No. 1.

ject of gas cleaning before the American Institute of Mining Engineers he contributed additional data on the subject.

His tables I. and II. from the first-mentioned paper are reproduced here and will repay careful study.

With clean gas the efficiency of the stove is raised considerably, according to Mr. Diehl's later figures, from 56 per cent. to 64 per cent. This is not a decrease of 8 per cent, but of 12½ per cent (8 ÷ 64) in the gas consumption of the stove and, what is much more important, it brings with it the possibility of obtaining higher blast temperatures with the given equipment of stoves and by this means reducing the coke consumption of the furnace.

Table I. shows the advantage of having a sufficient amount of heating surface for the given conditions and as the use of clean gas makes permissible the use of smaller checkers and thereby increases the heating surface, it may be said that the effect of clean gas is cumulative in its influence on stove design and operation. The best practice as brought out by Mr. Diehl's paper and its discussion favors the use of not less than four and preferably five square feet of heating surface per cubic foot of blast blown per minute measured by piston displacement. When four stoves are used this would mean from one to one and a quarter square feet of heating surface per stove for each cubic foot of blast blown per minute.

This will obviously vary to some extent with the conditions. When high heats are regularly required, as with the use of lean and refractory ores, more heating surface should be provided than with soft and reducible ores which ordinarily do not need such high heats. On the other hand, when there is no use for the surplus gas it may be better to save in the size of the stoves and burn the gas less economically in them to get the desired heat.

Since this article was written there have appeared accounts of recent experiments in Germany in which the heat imparted to the same was greatly increased by increasing the velocity of the gas through it, first by an air jet in the combustion chamber and in the later experiment by use of a fan to increase the draft. It is claimed that by the use of this system so much heat can be stored in each stove that only two are needed per furnace.

The accounts are too incomplete, and it is too early in the development to say what the final result will be, but with the vast improvement made in the operating conditions of stoves by clean gas there is no doubt that many improvements will follow and that increasing the velocity of the gas and blast through the checkers is one of the best ways to increase the rate of heat transmission.

As the efficiency of stoves increases it is very likely that fans will be used to provide draft for them for the reason that high efficiency can only come with low stack temperatures. Chimneys only provide good draft with fairly high temperatures and with a consequent waste of much heat. Therefore, it seems natural to expect that this conflict of requirements will be solved by the use of a fan whose performance becomes increasingly better as the temperature falls and which gives absolute control of conditions of draft, rate of combustion, etc.

The limit of possibility in reducing stove capacity is set by the amount of heat it is possible to store in a given weight of brickwork with a reasonable increase in its temperature, for if too great a drop in the temperature of the brickwork be necessary more gas is required and this limitation must be carefully considered in any plan for reducing the stove capacity.

Three stoves with clean gas and high gas velocity may easily be better than four without those advantages, but whether it will ever pay to reduce the number of stoves below three may well be doubted until overwhelming proof is offered.

**The Gun-crete Company** has opened its offices in the McCormick Building, Chicago. The firm specializes in cement gun work for engineering, industrial and mining structures, and also introduces the Weber system of workingmen's cottages, which, being constructed by the cement gun process, are fire, water and vermin proof, and can be built at a price almost as low as ordinary frame buildings. Other specialties of the firm are the lining and fireproofing of mining shafts and the lining of coal bunkers, etc. Mr. Carl Weber is the president of the Gun-crete Company.

**The question of pole supply** is one of increasing importance as power lines are extended in the West. A study of the value of different Rocky Mountain woods for poles is the subject of Bulletin 67, U. S. Department of Agriculture.

## Recent Chemical and Metallurgical Patents

### Gold and Silver

**Process for Canadian Silver-Cobalt Ores.**—In a patent granted to Mr. Oscar Dyckerhoff, of Karlsruhe, Germany, the inventor states that "a rational, cheap process, which permits the recovery of all the silver and at least the larger part of the cobalt, nickel and arsenic (from Canadian ores) has hitherto been wanting." He proposes a process of chloridizing, as more nearly fulfilling conditions than does any process now in use. Ordinary chloridizing-roasting is a failure when metallic silver exists in an ore in large proportions. The inventor finds, however, that chloridization of such material is easily effected if clay or ordinary loam be added to the mixture of ore and salt. This combination of materials results in the formation, at a suitable temperature, of sodium silicate and chlorine or hydrochloric acid, which latter attacks the silver. The alumina of the clay absorbs the silver chloride. The reactions will ensue at a lower temperature if iron or other pyrite is added to the roast.

The effect of thus roasting at a temperature not to exceed 600 deg. C., is to convert cobalt and nickel into a form (mainly basic sulphate) soluble in dilute acid formed from the roaster gases in absorption towers. The arsenic exists as sodium arsenate, and the silver as chloride cobalt, nickel and arsenic are extracted by means of weak tower acid, and silver by sodium thiosulphate. Several successive roastings and leachings may be necessary in order to secure high extraction. Cobalt and nickel are recovered by precipitation as sulphides, while arsenic may be obtained by crystallization as sodium arsenate. Silver is precipitated from its solution as sulphide. The inventor gives the results of tests showing extractions of 99 per cent of the silver, 69 per cent of the nickel and cobalt, and 95 per cent of the arsenic. These results were obtained, however, only by four successive roasting and leaching operations. (1,085,675, Feb. 3, 1914.)

**Roasting Precious-Metal Residue from Electrolytic Copper.**—The slime or mud resulting from the electrolysis of copper generally contains gold and silver which are recovered by smelting. In order to remove copper as completely as possible before smelting, the residue should be roasted to render copper soluble in sulphuric acid. Mr. **Rowland T. Wales**, of Chrome, N. J., has patented a form of roasting furnace, specially adapted to the roasting of these residues. The material is first filter-pressed, then granulated and placed in the furnace in shallow trays. The roast is given at a temperature of 600 deg. F. The use of trays avoids stirring of the charge, with consequent loss of dust, and permits each portion to be roasted according to its needs. (1,085,831, Feb. 3, 1914.)

### Lead, Copper, Nickel and Tin.

**Making White Lead.**—Roasting apparatus for producing white lead directly from lead ores has been patented by Mr. **Robert A. Stewart**, of Los Angeles, Cal. As shown in Fig. 1, the apparatus consists of a rotary roasting furnace 1, supplementary roasting chambers 23, and filter chamber 30. Suitable oil burners, consisting of an oil pipe, an air inlet and steam supply pipe, are placed in the rotary furnace at 14 and in the supplementary chambers at 28. The filter chamber has vertical partitions with movable, fabric-covered doors 36. A fan 33 induces a draft through the apparatus.

In the first operation in the drum, most of the lead is converted into oxide and carbonate, and the complete oxidation of the lead is accomplished in the supplementary chambers. The lead fume is retained in the filter chamber by means of the fabric-covered doors which are shaken from time to time by mechanism 44-46. The product may be removed through doors 37. (1,088,041, Feb. 24, 1914.)

**Hydrometallurgical Copper Process.**—The MacKay process for treating copper ores is one of a number of hydrometallurgical schemes proposed in the last few years. In a recent patent specification, Mr. **Henry S. MacKay** discloses the following features of his process. The ore is roasted at a low temperature in the presence of sulphur, whereby some of the copper is sulphated and rendered soluble in water. The ore is then leached with water, and the solution electrolyzed, copper being precipitated and sulphuric acid formed. The electrolyzed solution is then used as an acid leaching liquor for the extraction of the balance of the copper remaining in the ore as oxide or other form insoluble in water. The inventor finds a solution containing 2 per cent sulphuric acid and 2 per cent copper as sulphate is the best leaching liquor, and he preferably conducts his roasting and electrolyzing process in such a way as to maintain a standard solvent and electrolyte. Should he prefer to work with chloride instead of sulphate solutions, he adds salt in the roasting process, thereby obtaining a chloride electrolyte. (1,094,371, April 21, 1914.)

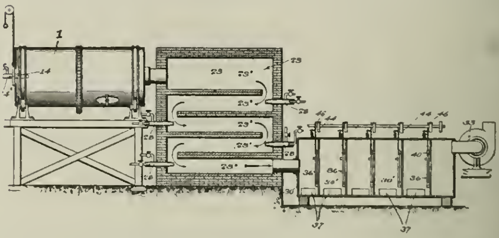


FIG. 1—APPARATUS FOR PRODUCING WHITE LEAD FROM ORES

**Sound Copper Castings.**—A method of producing castings of copper and silver, free from blowholes and of high electrical conductivity, is disclosed in a patent granted to Mr. **Charles L. Spinney**, of Lynn, Mass., assignor to the General Electric Co. Two or more parts of $B_2O_3$ for every 100 parts of the metal to be cast are placed with charcoal or other inert material in the bottom of a crucible. Copper is then placed on this mixture and superheated to a temperature of 1300 deg. C. It is covered with charcoal. The molten mass is then stirred with a graphite rod, whereupon the molten boric anhydride rises through the mass and removes dissolved and combined gases. Cast copper thus prepared has conductivity as high as 90 to 95% Matthiesen standard. (1,091,542, March 31, 1914.)

**Extraction of Nickel from Silicate Ores.**—Garnierite ores contain nickel in the form of a double silicate of nickel and magnesia. Garnierite occurs usually in a matrix of serpentine, with magnesia micas and other minerals which it closely approaches in specific gravity, so that ordinary methods of water concentration are ineffective. Messrs. **Henry L. Sulman** and **Hugh F. K. Picard**, of London, Eng., have devised and patented a process for the recovery of nickel from garnierite by use of a mineral acid in such quantity as to act as a selective solvent of the nickel.

It is impossible to dissolve all the nickel from garnierite by acid treatment with dissolving also a large quantity of magnesia. But if the quantity of acid be limited to about 25 per cent of the weight of the ore, undue solution of magnesia is avoided. Weathered ores yield more magnesia to the solution than do freshly crushed ores.

The material is crushed to 30 or 50 mesh and treated with concentrated sulphuric acid (and some salt if desired—25 per cent acid and 10 per cent salt). Enough water may be added to form a paste, and the well mixed mass is heated to 120-130 deg. C. The soluble salts are then extracted by water, preferably hot and slightly acid, and the solution removed by a filter press. The nickel is precipitated as hydrate from this solution by stirring in powdered MgO. (1,091,545, March 31, 1914.)

**Recovery of Tin.**—A simple method of producing commercial tin from the mixture of finely divided tin and tin oxide resulting from the treatment of tin scrap, Mr. William Hoskins, of Chicago, Ill., proposes a special form of furnace. The shaft is equipped with rows of tuyeres at three different levels. It is filled with carbon to a level above the upper tuyeres, the fuel being maintained in a state of incandescence throughout, but at a higher temperature in the upper part of the furnace. The metal mixture is charged onto the incandescent mass in a reducing atmosphere where tin oxide is reduced, and all the metal flows to the bottom of the shaft where it is withdrawn. (1,088,422, Feb. 24, 1914.)

### Metallurgical Furnaces

**Metallizing Furnace.**—The process of reducing an ore or oxide of a metal without fusion of the charge, known as metallizing, is receiving some attention as a possible means for producing an iron precipitant for copper solutions. A modified form of McDougall furnace is suggested and patented by Messrs. **E. P. Mathewson** and **Frederick Laist**, of Anaconda, Mont., as a suitable means of producing metallized iron, or "sponge" iron. According to the modification, a six-hearth furnace, for example, receives partly roasted ore, and completes the desulphurization and oxidation on the three upper hearths. On passing from the third to the fourth hearth, the ore receives an addition of crushed coal from a bin outside the furnace. The fourth and fifth hearths, where the reduction of iron oxide to iron takes place, are muffle hearths, suitably heated. Air is excluded from the three lower hearths and the final reduction takes place on the bottom hearth. The product is withdrawn from hoppers into which the ore flows from the bottom hearth. The roasting or oxidizing hearths are heated by oil burners, and the reducing hearths derive their heat from the admixed coal. Separate means are provided for withdrawing the different gaseous products from the upper and lower portions of the furnace. (1,094,802, April 28, 1914.)

**Heat Conservation in Roasting Furnace.**—According to a patent of Mr. **Utley Wedge**, of Ardmore, Pa., air heated by its passage through the rabble arms of the upper hearths of a furnace is delivered into the lower hearths through perforations in the rabble arms in those hearths. The heat derived from this air aids in maintaining combustion. (1,094,953, April 28, 1914.)

**Furnace for Volatilizing Sulphur from Sulphide Ores.**—In Fig. 2 is shown a modification of the Wedge furnace, in which the inventor has provided a construction for carrying on operations not easily performed in the ordinary furnace. Projecting upwardly from the hearths are annular ribs 11 which divide the hearths into inner and outer zones 12 and 13. The rabbles are adapted to work material in both zones. Different feed and discharge points are provided for the material going into and leaving each zone. Thus, for example, carbonaceous fuel may be burned in the outer zones and pyritic ore in the inner zones, the combustion of the carbon providing a reducing atmosphere in which sulphur may be volatilized. Steam may be introduced into those hearths where vaporization of the sulphur and oxidation of the metal is proceeding. This type of furnace is of interest in connection with the Hall process for roasting ores. (1,094,954, April 28, 1914.)

**Lining Furnaces.**—A method of lining and repairing furnaces of the open hearth type, while hot, is patented by Mr. **Byron E. Eldred**, of New York City. The method consists in projecting across a hot furnace, and to the point of use, a mixture of dolomitic lime and coal tar, or like substances, by means of a jet of products of combustion drawn from the stack of the furnace or other source. The material is protected against combustion of the binder in its passage across the furnace, and a dense, hard lining or patch can be readily made. (1,091,567, March 31, 1914.)

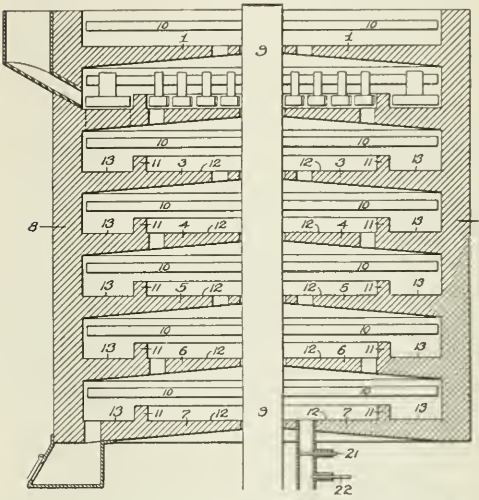


FIG. 2—FURNACE FOR VAPORIZING SULPHUR FROM SULPHIDE ORES

### Alloys

**Iron-Nickel-Copper Alloy.**—The use of Monel metal in producing both high and low range alloys of this type, as well as their production directly from ore containing nickel, copper and iron in the form of sulphides, is the object of a patented invention of Mr. **Guilliam H. Clamer**, of Philadelphia, Pa. To make a low range alloy from ore, a matter is first produced, which is roasted and then reduced, yielding a homogeneous alloy of the three metals. (1,086,314, Feb. 3, 1914.)

**Titanium Carbide.**—The production of a metallic compound useful in removing occluded impurities from metals, is patented by Messrs. **Auguste J. Rossi** and **William F. Meredith**, of Niagara Falls, N. Y. Iron, titanium oxide and carbon are charged in a crucible of an electric furnace. Conditions of time and temperature are maintained which result in the production of the most possible titanium carbide throughout the bath. The mixture is then promptly cast to avoid formation of graphitic carbon. The product is useful as a purifying agent when added to molten metals. (1,094,022, April 21, 1914.)

**Low-Carbon Ferro-Alloys.**—The production of ferrovanadium, ferro-uranium, ferro-chromium, etc., low in carbon, can be accomplished without using such agents as silicon, aluminium, ferro-manganese, etc., according to a patent granted to Mr. Warren F. Bleecker, of Canonsburg, Pa. The inventor first reduces a suitable metallurgical mixture to produce a ferro-alloy high in carbon, and then mixes with it a calculated amount of unreduced oxides and slag-forming material, so that the excess carbon in the alloy first produced will reduce the oxides subsequently added. The result is an alloy unusually low in carbon. (1,094,114, April 21, 1914.)

## Synopsis of Recent Chemical and Metallurgical Literature

### Gold and Silver

**Volatilization of Metals as Chlorides.**—Reference to the process of volatilizing metals from sulphide ores by roasting with salt has been made in this journal, April and May, 1913, pages 220 and 230, respectively, and in February, 1914, pages 71 and 137. Readers who are interested in this metallurgical process will find a valuable contribution by Mr. STUART CROASDALE, in *Mining Magazine*, March, 1914. The author was one of the inventors of the process in this country about fifteen years ago. Last year Mr. Ben Howe, of Australia, announced a similar process. In the article here referred to, Mr. Croasdale compares at great length the details of his own and Howe's work, and shows remarkable concordance of results and similarity of experience on the part of both. In concluding his comparison Mr. Croasdale says:

"It seems to me that no more convincing testimony of the metallurgical soundness of this process could be given than this independent duplication of my work from beginning to end by Mr. Howe, ten years after my work was published. As will be seen, the greatest difficulty in both cases was mechanical, namely, securing a satisfactory apparatus for collecting the fume. I believe this can now be easily solved." The last remark refers to condensation by means of a high-potential electric discharge.

**Benefits of Fine Grinding on the Rand.**—According to a note in the *South African Mining Journal*, the results obtained by the new tube mill plant of the Knights G. M. Company afford a good example of the benefits to be derived from fine grinding. Five tube mills, 16 ft. 6 in. by 6 ft., have been added to the mill equipment, with the usual accessory apparatus for classifying the feed and amalgamating the discharge. The full equipment of 245 stamps and five tube mills is now capable of crushing 45,000 tons of ore per month. The value of the tubes lies more in increasing the extraction than in raising the tonnage.

In September last, before the tube mills were used, the tailing sent to the dump had a gold value of $0.487 per ton. In the last quarter of the year, following the use of tube mills, the value of tailing was reduced to $0.262. This represents a gain of $0.225 per ton. Milling cost was increased by about $0.12 per ton. Further reduction in tailing value and working cost is anticipated.

**Sand Leaching at Oroya Black Range, Western Australia.**—The monthly *Journal* of the Chamber of Mines of Western Australia for January, 1914, contains an article on this subject by Mr. W. B. CHOMLEY. The ore is an oxidized quartz in which a large proportion of the gold is deposited on the cleavage planes of the shattered crystals. Fine crushing is unnecessary, and leaching is simple. The sand treated by leaching comprises 54 per cent of the ore milled. Crushing is done by stamps through 20 and 14-mesh screens, one battery which receives the greater proportion of soft ore being equipped with 14-mesh screens. Recovery by amalgamation, both on plates and in grinding pans, amounts to 65 per cent of the total.

The arrangement of the leaching plant is unusual. Eight vats are arranged in two rows of four each, elevated on timber framework, 12 ft. from the surface. Two collecting tanks on movable platforms run on a triple line of rails, one above each row of treatment vats. A central launder extends between and above the two rows of treatment vats, and has branch launders through which the stream of pulp can be diverted to the collecting tanks wherever they may be.

When a vat is to be filled the collector is run to a point above it, and the stream of pulp is distributed into the collector. The slime overflows to the vacuum-treatment plant. The collector being filled, it is allowed to drain for ten hours, after which the charge is shoveled into the treatment vat below, through two doors in the bottom of the collector. After leaching, the treatment vat is discharged in a similar manner into cars beneath. The accompanying table gives details of treatment.

Charge 85 tons dry sand

| Solution | % KCN | Time, | Hours | % KCN Coming Off |
|---|---|---|---|---|
| 25 Tons Strong | 0.25 | Pumping<br>Soaking<br>Draining | 5<br>8<br>19 | .01 to .05 |
| 20 Tons No. 2 Sump | 0.07 | Pumping<br>Soaking<br>Draining | 5<br>1<br>18 | .06 to .08 |
| 25 Tons No. 3 Sump | 0.03 0.05 | Pumping<br>Soaking<br>Draining | 5<br>1<br>18 | .04 to .06 |
| 25 tons No. 3 Sump | 0.03 0.05 | Pumping<br>Soaking<br>Draining | 5<br>1<br>18 | .03 to .05 |
| 30 Tons No. 3 Sump | 0.03 0.05 | Pumping<br>Draining<br>Vacuum | 5<br>21<br>4 | .03 to .05 |
| 125 Tons | | | 134 | |

No water wash is used, the weakest zinc-box tailing solution being applied for washing purposes.

The following is an average of costs for three months, and includes disposal of tailing.

| | Cents per Ton |
|---|---|
| Labor and salaries | 21.64 |
| Power | 4.04 |
| Repairs | 2.34 |
| Assaying | 2.04 |
| Cyanide | 16.32 |
| Sundries | 0.62 |
| Disposal of residue | 27.46 |
| Total | 74.46 |

The author calls attention to the value of allowing the charge to drain after each application of solution, thereby permitting oxygen to permeate the mass and aid in the solution of the gold. The practice of mixing some slime with sand is condemned on account of the practical impossibility of getting a permeable mass into which oxygen can enter.

### Zinc, Lead

**Preferential Flotation of Zinc Sulphide by the Horwood Process.**—Our last issue contained a note on the adoption of the Horwood process by the Zinc Corporation, Ltd., Broken Hill, N. S. W. The information there given is supplemented by the present review of an article by Mr. E. J. HORWOOD, published in the *Proceedings* of the Australasian Institute of Mining Engineers, No. 12, 1913.

The material being treated is a mixed zinc-lead flotation concentrate, too fine to be separated on concentrating tables. Hitherto it has been sold to zinc distillers as a low-grade concentrate. As it is not a desirable product, the producer is unable to obtain much value for the metals contained, particularly lead and silver. The importance of recovering these two metals in form suitable for lead smelting, as well as of raising the grade of the zinc content, is easily appreciated.

Being a preferential *zinc* flotation process, it offers advantages in treating slime concentrates produced from old dumps in which the lead particles have become slightly oxidized and are, therefore, not suited to a preferential *lead* flotation scheme. If the whole of the sulphides in any slime be first floated as mixed concentrates and then subjected to the Horwood process, a very high-grade zinc concentrate can be obtained, with a maximum recovery of the semi-oxidized lead and silver as a separate product.

A new feature of importance added last year was the preliminary washing of the mixed concentrates with clean water to remove soluble salts before roasting. This has resulted in diverting to the lead product a much higher percentage of the silver content, and has made possible an effective separation of lead and zinc with a lower degree of sulphatizing in the roast.

The Zinc Corporation's plant has a capacity of 500 tons per week. Pulp is thickened and then filter-pressed. The washing process mentioned takes place in the press, and the cake is finally discharged with about 10 per cent to 12 per cent moisture. It is then roasted in an Edwards furnace, in which the fuel consumption is 4.8 per cent of the ore charged. Coal is burned in six fireboxes arranged on both sides of the furnace. Draft is induced by a fan. The degree of sulphatization necessary for the process ranges about 30 per cent of the lead content.

The roasted product is then treated by flotation, whereupon the zinc floats and the lead and silver largely remain behind. Sulphuric acid consumed amounts to from 20 lb. to 27 lb. per ton. Eucalyptus oil is used at the rate of 1 lb. per ton, some being added to each of the ten boxes. Following are typical plant results:

| | Zinc, Per Cent | Lead, per Cent | Silver, Oz. per Ton |
|---|---|---|---|
| Feed to roaster | 39.0 | 16.0 | 18.0 |
| Zinc concentrate | 49.5 | 6.0 | 11.0 |
| Lead residue | 9.0 | 47.0 | 45.0 |

The financial result shows a net profit of about $15 per ton, considering the zinc concentrate as 71 per cent and the lead residue as 24 per cent of the original mixture.

### Reverberatory Furnaces

The utilization of the hot gases escaping from a reverberatory furnace, as a source of power, is general practice in connection with copper smelting. In a paper published in the Mining Magazine, February, 1914, Mr. **Arthur E. Williams** contributes calculations bearing on the amount of heat that may thus be utilized in connection with oil-fired reverberatories. He considers the case of a modern furnace, 100 ft. long by 19 ft. wide, using crude oil of the following composition: 84.2 per cent C, 12.4 per cent H, 3.4 per cent O, having a calorific value of 19,296 B.t.u. A summary of his calculations leads him to the conclusion that a properly designed and operated waste-heat plant in connection with oil-fired reverberatories should yield in steam the equivalent of 50 per cent of the calorific value of the oil. Turbo-generators would yield 0.36 kw. or 0.48 electrical hp. for each pound of oil burned in the furnace.

## Notes on Chemistry and Metallurgy in Great Britain

*(By Our Special Correspondent)*

### Tungsten and Nickel High Speed Steels

A paper by Prof. J. O. Arnold and A. A. Reed on "The Carbides of Tungsten and Nickel Occurring in Steels" was recently read before the Institution of Mechanical Engineers.

In their introductory remarks the authors mentioned that although the importance of the subject might not be manifest to engineers, yet the work done by Abel and Deering on carbide of iron was a great cornerstone in the metallurgy of steel, and, therefore, for the benefit of engineers; because it appeared to them that advances in the metallurgy of steel had been followed by marked advances in mechanical engineering. It was not possible to acquire a complete knowledge of high-speed steels until the state of the existence of the carbides therein was well understood; and any importance which attached to the present paper was due to its dealing with tungsten, the essential element of high-speed steel, and with nickel, an equally vital component of the best structural steels.

The tungsten steels employed in the investigations contained from 0.67 to 0.73 per cent of carbon and from 2.38 to 26.29 per cent of tungsten. The carbides were separated by an electrolytic method, and the results showed that in the steel, with 0.7 per cent of carbon and 9.74 per cent tungsten, practically the whole of the iron carbide had disappeared, and the carbide of tungsten nearly corresponding to the formula $W\,C$ had replaced it. That tungsten carbide should theoretically contain 93.88 per cent tungsten and 6.12 per cent carbon. In the case of steels containing 14.96, 21.15 and 26.29 per cent tungsten, the carbon falls and the iron rises as the tungsten rises, and this leads to the idea that a stable tungstide of iron exists with the carbide of tungsten.

In preparing ferro-tungsten at Sheffield University it had been found that the high specific gravity of this tungstide prevented the production of a homogeneous alloy in the crucible. When making pure 40 to 50 per cent ferro-tungsten from metallic tungsten and Swedish bar iron, it is always found that there is a fluid part which pours easily and a liquated portion at the bottom which can hardly be poured at all on account of its very high solidifying point. It adheres to the crucible in a pasty state, and when cold is only drilled with great difficulty by an especially hard drill which easily cuts very hard chilled white iron, and its hardness, therefore, must be nearly that of feldspar. In one melt the fluid portion of low solidifying point contained 38.2 per cent of tungsten and weighed about 14½ lb. The portion of higher melting point which remained in the crucible contained 52.3 per cent of tungsten, and its weight was about 13 lb. This latter metal has a composition approximately to the formula $Fe\,W$. On account of this liquation it is quite impossible to prepare a homogeneous large bar of high-speed steel—for example, from a 2-ton ingot—the bottom of the ingot always contains considerably more tungsten than the top, and the larger the proportion of tungsten employed the greater is the difference between the tungsten content at the top and the bottom of the ingot.

Photo-micrographs of tungsten steels clearly showed the presence of three new components; namely, tungsten pearlite, tungsten cementite and tungsten hardenite. The pearlite is usually of a fine granular or minutely laminated structure, characteristic of the sorbitic variety of pearlite; the cementite was obtained in nodules, similar to iron cementite, by annealing the tungsten alloys, owing to the segregation of the $WC$ of the pearlite. The hardenite forms slowly and progressively from the pearlite. Beginning about 830 deg. C. the transformation is apparently complete at about 1150 deg. C.

The steels, which contained 14.96 and 21.15 per cent of tungsten with 0.7 and 0.73 per cent of carbon respectively, were easily filed when quenched at 860 deg. C.; when quenched at 1000 deg. C. they were hard, but could still be filed; but when quenched at 1190 deg. they were sufficiently hard to strip the files.

These facts go to prove the progressive formation of tungsten hardenite; and though these facts have been known for possibly twenty years to practical men, the authors believed that the scientific explanation was given for the first time in their paper.

With regard to nickel steels, the authors were of opinion that in ordinary manganese structural steels containing up to 7 per cent of nickel, the nickel is not combined with the carbon, but forms alloys with the iron and the manganese, and that a definite alloy of iron and nickel is formed corresponding to the formula $Fe_7Ni$, a substance which is possibly one of the most remarkable in the metallurgy of iron.

Sir Robert Hadfield suggested they should make a set of nickel alloys, as free as possible from carbon, silicon and manganese. He predicted that alloys of nearly pure iron and nickel would show a critical mechanical point at something between 11 and 15 per cent of nickel. Experimentally the tests fulfilled the prediction, but the effect of carbon and silicon and higher manganese on such alloys was to produce surprising ductility, giving 11 per cent elongation, 46 per cent reduction of area, a bending angle of 167 deg.; a yield point of 39 tons and a maximum stress of 88 tons per square inch for the 13 per cent nickel steel.

A nearly pure 7 per cent nickel-iron has almost the same mechanical properties as an iron containing 33.5 per cent nickel, namely, a yield point of 30 tons, a maximum stress of about 38.5 tons per square inch; an elongation on 2 in. of about 30 per cent, and a 37 per cent reduction of area. A curve of tenacity for nearly pure nickel iron with observation points at 7, 13 and 33 per cent nickel the greatest stress is shown at 13 per cent, which corresponds to the formula $Fe_7Ni$. The consequent existence of a definite alloy of iron and nickel having that composition is extremely possible.

## Scottish Shipbuilding

During February 27 vessels with a tonnage of 55,687 were launched from Scottish yards, making a total of 46 vessels and 86,500 tons for the two months, out of which 32 vessels of 71,354 tons were built on the Clyde.

Although new orders placed are far from numerous there is no immediate probability of work slackening in the yards.

## Company Meetings

*Sir W. G. Armstrong Whitworth & Co.*

Annual general meeting, April 18. A total dividend for the year of 2/6d. per share on the ordinary shares was declared and £56,559.14.9 went for dividends on the preference shares, the total sum thus absorbed being £568,122.4.9, leaving a balance of £323,716.2.3 to be carried forward to next year's accounts.

*Mason & Barry.*

Annual general meeting, April 27. A dividend of 7/- per share was declared, the same as last year. After placing £20,000 to reserve for contingencies, and £1,000 as usual to Staff Pension Fund, the balance carried forward was £15,550, as against £25,148 last year.

*Consolidated Malay Rubber Estates.*

Annual general meeting, April 23. Total dividend of 50 per cent for the year was declared, and it was announced that the cost of production had been materially lowered.

*Bell's United Asbestos Co.*

Annual general meeting, April 20. The ordinary dividend declared is the same as for the last four years, namely, 12½ per cent; £5,000 goes to reserve, as against £15,000 in the previous year, 1912, and more than £3,000 more is carried forward.

*Brush Electrical Engineering Co.*

Annual general meeting, April 20. The chairman announced that the business of the company had improved very satisfactorily. It was proposed to reduce the preference shares to a nominal value of 7/- and the ordinary shares to a nominal value of 5/- each, with a view of being in a position next year to pay a dividend on the reduced capital.

## Market Prices

April, 1914

| | £ s. d. |
|---|---|
| Aluminium ingots, ton lots | 86. 0. 0 |
| Alum, lump, loose, per ton | £5.5.0 to 5.10. 0 |
| Antimony, Star Regulus, ton | 28.10. 0 |
| Borax, British refined, crystal, cwt | 17.10. 0 |
| Copper sulphate, ton | 21.15. 0 |
| Caustic soda, 70% ton | 10. 0. 0 |
| Copper ore, 10% to 25% per unit | 10/9 to 11. 3 |
| Ebonite rod, lb | 4. 6 |
| Hydrochloric acid, cwt | 5. 0 |
| India-rubber, Para, fine, lb | 2.11½ |
| Mica, in original cases, medium | 3/6 to 6. 0 |
| Petroleum, Russian spot, gal | 9¼ |
| Quicksilver (Spanish) bottle | 7. 0. 0 |
| Sal-Ammoniac, cwt | 2. 2. 0 |
| Sulphate of ammonia, ton | 12. 3. 9 |
| Sulphur, recovered, ton | 5.10. 0 |
| Shellac, cwt. | 3.15. 0 |
| Platinum, oz., nominal | 9. 5. 0 |
| Tin ore, 90%, ton | £96.0.0 to 98. 0. 0 |
| Zinc, Vielle Montagne | 25.12. 6 |

Copper opened £64.15.0 and soon hardened, being £65.18.9 by the 8th. After the holidays it was lower at £64.5.0 (14th) and £64.17.6 (15th), falling away to £64.7.6 (20th) and, after a short recovery, to £63.5.0 (24th). Since slightly higher and closing £64.0.0.

Tin opened £172, but fell away till it touched £167.7.6 (8th). After the holidays it opened £166, weakening for a few days, then regaining to £166.5.0 on the 17th. It declined sharply later, reaching £161.10.0 on the 22d and £155.10.0 on the 24th, closing £156.15.0.

Lead opened £18.10.0 and rose to £18.15.0, which price was maintained from the 7th to the 16th. It then fell to £18.10, remaining so till the 23d. On the 24th again rose to £18.15.0, and by the 27th had reached £19.15.0 and closes £19.5.0.

Hematite has been steady at 61/- and closes same price.

Scotch pig opened 56/- but rose smartly to 57/6 (7th), after the holidays (14th) it opened 57/3 and then fell slowly to 56/7½ on the 22d, recovering to 56/10½ on the 23d. Closes 57/6.

Cleveland opened 50/- and rose to 51/6 by the 7th, thence fell to 51/3, which was maintained till the 14th; on the 15th 50/10½ was registered, the price then fell off to 50/7½ on the 22d, after which a recovery to 50/10½ on the 23d. It closes 51/4½.

## Differences

| Higher | £ s. d. | Lower | £ s. d |
|---|---|---|---|
| Aluminium, ton | 1. 0. 0 | Copper sulphate | 15. 0 |
| Shellac, cwt | 3. 6 | Sul. of Ammonia | 3 6 |
| Scotch pig | 1. 6 | India-rubber | 0½ |
| Cleveland | 1. 4½ | Tin ore | 11. 0. 0 |
| | | Copper | 15 0 |
| | | Tin | 15. 0. 0 |

---

The **American Institute of Mining Engineers** will hold its autumn meeting in the week from Monday, Aug. 10, to Saturday, Aug. 15, in Salt Lake City, Utah.

## The Lavoisite System of Generating Oxygen

For the art of autogenous welding, and the cutting of steel, there are at present four commercial methods of generating oxygen. Probably the user of oxygen for such purposes is most familiar with bottled oxygen, as produced by the Linde process.

Second in volume to the bottled oxygen as produced by the Linde process is that produced by the decomposition of water, which is also distributed in bottles, under high pressure, and is commercially known as electrolytic oxygen. Electrolytic cells are now also installed in manufacturing plants, making it possible for such manufacturers to produce their own oxygen, thereby doing away with the inconvenience incident to the use of bottled oxygen.

The production of oxygen by the use of chlorate of potash and manganese dioxide is now widely known, and there are several small installations of such plants throughout the country.

The Lavoisite system, though not so well known, is in fact a much older method of producing oxygen than any of the previously mentioned systems. Its introduction into general use for the generation of oxygen, in connection with the art of oxy-acetylene welding, has been slow, for the reason that up to within a comparatively short time a practical commercial generator had not been designed that would work successfully in connection with this method of generating oxygen, and in this respect the Lavoisite process is similar to a great many other chemical processes, the commercial efficiency of such depending entirely upon a design of apparatus that will carry out the chemical reactions in an efficient and reliable manner.

Lavoisite, so called in honor of the celebrated French chemist Lavoisier, whose name is so intimately associated with oxygen, is a specially prepared calcium hypochlorite, which, when put into solution, a suitable and proper amount of catalyzer being added and the solution simultaneously being heated to 90 deg. C., rapidly generates oxygen of a purity that is unsurpassed by any of the processes that are now in commercial use. Tests from plants in operation showing the oxygen from Lavoisite to be practically 100 per cent pure.

In the early days of the art of oxy-acetylene welding the purity of the oxygen was not given much thought. It soon became evident, when the users of oxygen became familiar with the art of autogenous welding, that the purity of the oxygen was of the greatest importance, as the results obtained by the use of pure oxygen against impure oxygen were such that even a slight difference of only 1 per cent would show inferiority in the quality of the weld, the time to accomplish the work, the amount of oxygen and acetylene used also being affected. This is most pronounced in the cutting of steel, where a difference of only a fraction of 1 per cent will greatly affect the time of cutting and quantity of oxygen used.

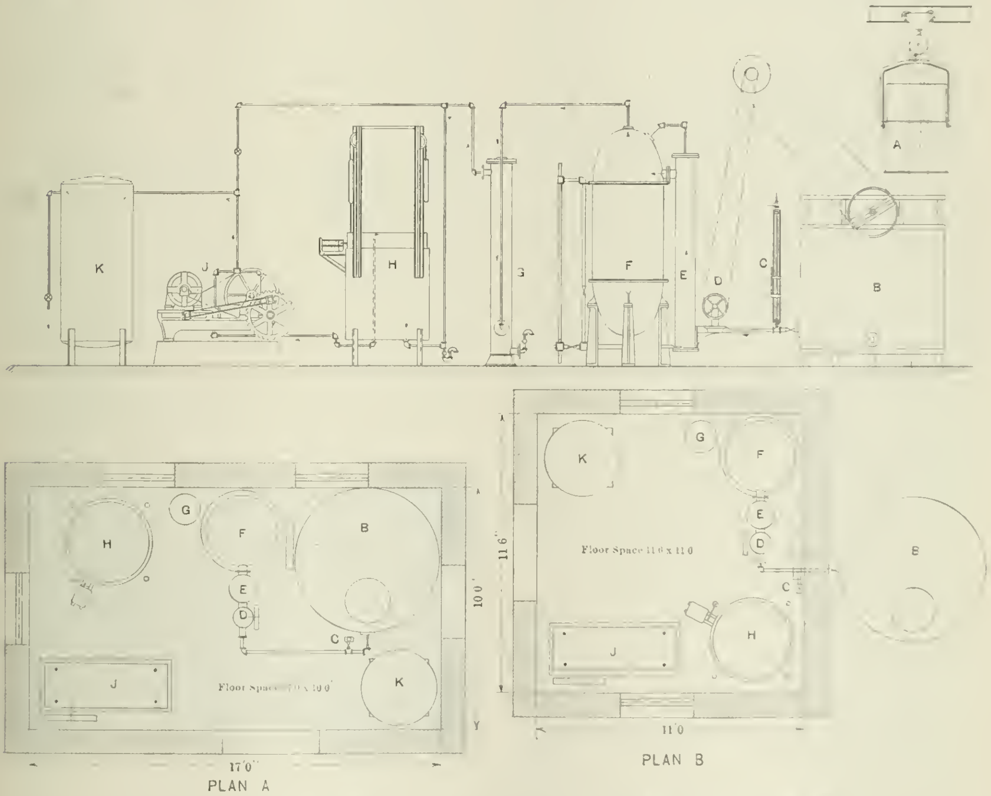


FIG. 1—PLANS AND VERTICAL SECTION OF LAVOISITE OXYGEN-GENERATING SYSTEM

A loader, B mixing tank, C indicator, D pump, E heater, F generator, G scrubber, H gas-holder, J compressor, K pressure-tank.

The operation of the Lavoisite generator is best described in U. S. patent No. 1,031,017, covering this apparatus, the efficiency of its operation depending upon the regulation and direction of the flow of the Lavoisite solution through the apparatus.

Lavoisite is shipped in large hermetically sealed steel drums, holding about 800 lb. of Lavoisite. The Lavoisite is charged into tank *B*, shown in Fig. 1. A loading device of special design is furnished for lifting the drums from the floor and conveying them to the mixing tank *B*. The loader is equipped with doors that open downwards upon releasing a catch, thereby discharging the contents of the drum into the mixing tank. Sufficient water is then added to bring the mixture up to the required consistency. An indicator *C* shows the required amount of water to be added, according to the weight of Lavoisite placed in the mixing tank. This indicator does away with any necessity of calculation on the part of the attendant in charge of the plant as to the proper strength of the Lavoisite liquor in the mixing tank, which it is essential to keep within a few degrees of the correct gravity.

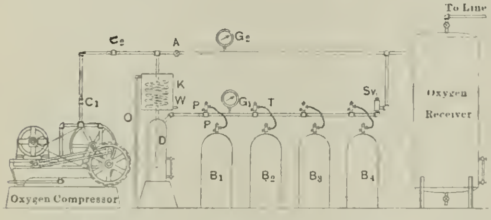


FIG. 2—METHOD OF COMPRESSING LAVOISITE OXYGEN INTO CYLINDERS FOR PORTABILITY IN USE THROUGHOUT CUSTOMER'S PLANT

A globe valve on receiver line, $B_1$, $B_2$, $B_3$, $B_4$ oxygen bottles, $C_1$ vertical ball check valve, $C_2$ horizontal swing check valves, D separator, K condenser, $G_1$ high pressure gauge, $G_2$ low pressure gauge, O water overflow, P pressure valves, $S_v$ savety valve, T copper tubes, W water inlet.

Mixing tank *B* is equipped with an agitating device to assist the Lavoisite in going into solution, and during the generation of oxygen this agitator is slowly, yet constantly, stirring the contents of the mixing tank.

The liquor passes from the mixing tank to the pump *D*, which forces it into heater *E*. Connected with pump *D* is a small pump for simultaneously forcing catalytic liquor into the heater *E* in the correct proportion to Lavoisite liquor being pumped by pump *D*.

The heater *E* is equipped with a thermostat which controls the amount of live steam admitted to heat the liquor coming from the pump, so that regardless of the speed of the pump over a given range, the temperature of the heater remains constant. The Lavoisite and catalytic liquor enter at the bottom of the heater and are brought quickly up to a temperature of 90 deg. C., when oxygen is rapidly generated; it is here necessary that the liquor in the heater travel in the same direction as the liberated oxygen.

About 90 per cent of the reaction takes place in the heater. The oxygen liberated passes through a pipe connected to the top of the heater to the generator *F*. The partly finished liquor passes through a pipe in the side of the heater to the generator *F*, within which the reaction is completed, the spent liquor overflowing through the pipe shown at the side of the generator. The passage of the liquor through the generator is in reverse direction to that of the oxygen; consequently the liquor that has been unacted upon, in its passage through the heater, comes into more intimate contact with the catalyzer in the generator *F*, with the result that the liquor leaving the generator is entirely depleted of its oxygen content.

The oxygen leaving the generator passes through the scrubber, or cooler, *G*, where it is reduced in temperature, and any moisture mechanically carried over from the generator is condensed out. From the scrubber the oxygen passes to a gas-holder *H*, the bell of which is counterbalanced.

The rise and fall of this bell actuates a tank switch, which automatically cuts in and out the compressor *J*. The pressure of the oxygen up to the compressor is slight, in practice about equal to a column of water 2 in. high. The compressor raises this pressure up to any desired point, usually 75 to 100 lb., and stores the oxygen at this pressure in the pressure tank *K*.

A pipe shown at the left of the pressure tank conducts the oxygen to any point where it is desired to use it, the usual reducing valves being placed on outlets from this pipe to reduce the pressure suitable to the torch being used.

The capacity of the Lavoisite generator is very flexible, the quantity of oxygen produced being controlled by the speed of the pump *D*, which is fitted with a cone pulley, making it possible to generate oxygen from 50 cu. ft. per hour to 500 cu. ft. per hour. This is of great advantage to the welder, as it enables him to keep pace with his work by simply speeding up the apparatus, doing away with the necessity of having numerous or large tanks of oxygen under high pressure.

Tests of the oxygen have shown a purity as high as 99.9 per cent. The purity of Lavoisite oxygen is such, in fact, that for the cutting of metal it is not necessary to run the pressure above 50 lb. for all ordinary work. If, however, it is desired to compress to a higher degree than that usually carried in the pipe lines, an outfit such as is shown in Fig. 2 is used, which allows the consumer to compress the oxygen into bottles, up to a reasonably high pressure, 300 to 400 lb., for portable and local use about his plant.

Plans of typical installations of Lavoisite plants are shown in Fig. 1. It will be seen to be possible to place in a building 11 ft. square a generator capable of producing 500 cu. ft. of oxygen per hour.

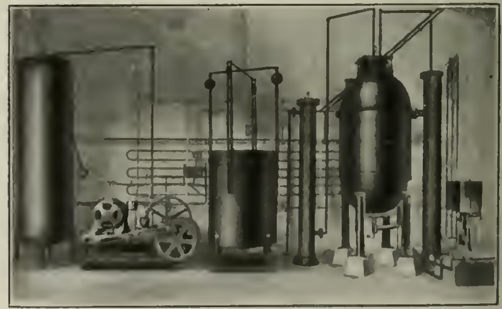


FIG. 3—LAVOISITE OXYGEN-GENERATING PLANT, 50 TO 500 CU. FT. OXYGEN PER HOUR

The operation of the generator is automatic and continuous, so long as it is supplied with liquor from the mixing tank *B*, and this tank can be charged from time to time without affecting the generator. In shutting down it is necessary only to stop the feed pump *D*, when the generation of oxygen ceases.

Fig. 3 is a view of an installation with a capacity of from 50 to 500 cu. ft. of oxygen per hour. The mixing tank is here not shown, it being placed on the outside of the building. The pipe shown projecting through the wall at the right in the photograph connects with mixing tank. The illustration clearly shows the several parts of the apparatus. There are, however, numerous pipes shown in the photograph having nothing to do with the Lavoisite generating outfit, they being water pipes for heating and water supply to the welding shop.

Lavoisite is noncombustible, so that large quantities can be stored without danger. This makes it possible for the user to have at his command his supply of oxygen in a convenient form to meet the varying demands of his daily needs. Sufficient quantity of Lavoisite is usually charged into the mixing tank in the morning to last throughout the day; this is a matter of a half hour's work, so that it is not necessary to employ additional labor to do this work, the ordinary shop helper being fully capable of charging the Lavoisite plant.

Lavoisite is sold by the Castner Electrolytic Alkali Company under an agreement with the purchaser that every pound of Lavoisite will produce 1 cu. ft. of oxygen, when used in the generators designed for its use and operated according to instructions given. The apparatus, and all pertaining thereto, are manufactured by the Castner Electrolytic Alkali Company, Niagara Falls, N. Y. Some of the plants now installed by this company are capable of generating upwards of 5000 cu. ft. of oxygen per day of ten hours.

---

The **New York Section** of the **American Electrochemical Society**, in its meeting on May 22, elected Dr. Colin G. Fink chairman for the coming year and reelected Mr. H. B. Coho secretary and treasurer. A vote of thanks was extended to the retiring chairman, Mr. Lawrence Addicks, now in Douglas, Arizona, for the extraordinarily effective work done by him for the society during the past year.

**Detachable Link-Belt** is the subject matter of a very interesting and freely illustrated book just issued by the Link-Belt Company of Chicago as Section A of Catalog 110. Detachable link-belt was invented by William D. Ewart in 1873, and from that time the original has been manufactured solely by the Ewart and Belmont Works of the Link-Belt Company.

**Feed-Water Difficulties.**—"The problem of suitable feed water, although less serious in New England than in other parts of the country, is still a trouble maker in many plants. The formation of scale and the softening of water are due to the simplest of chemical reactions, and by an analysis of the water a competent chemist can readily predict in advance the proper amounts of suitable chemicals necessary to prevent scale or corrosion, and not only save the company the expense of frequent boring and replacing of tubes, but obviate the necessity of attempting to force heat through the same substance with which many of your steam lines are insulated. The service of a chemist," said Mr. Carl F. Woods, secretary of the firm of Arthur D. Little, Inc., of Boston, when recently speaking before a group of street railway operators, "would prevent the purchase of a special compound at $1,000 a year which consisted of 97 per cent water and 3 per cent molasses, or obviate the necessity of purchasing a mixture of soda ash, tannin and water under a brand name at 8 cents a pound when the principal ingredient can be obtained for 1 cent a pound."

**Lead and Zinc in Kansas and Arkansas.**—The value of the lead and zinc produced at mines in Kansas in 1913 was $1,343,432, compared with $1,680,744 in 1912, according to J. P. Dunlop, of the United States Geological Survey. In Arkansas the value was $55,120 in 1913, compared with $106,014 in 1912.

## Accelerators for Gasoline Gas Plants

BY C. J. BARTON

The laboratory in which the writer worked was equipped with a gasoline gas machine. In the summer no trouble was experienced in securing a good gasoline gas for the laboratory but in winter the gas became so weak that it would hardly burn. The apparatus consisted of a large drum-shaped low-pressure air-compressor which compressed air to about 10 in. of water. The drum was driven by a large weight which was periodically wound up by hand. The gasoline was kept in a large underground tank outside of the laboratory. The gas machine was a surface machine, the air from the compressor passing over the surface of gasoline in the tank then through a pressure regulator, where the pressure was reduced to about 1 in. of water, then into the gas line.

It was almost impossible to do any analytical work with the weak gas obtained in the winter time so the writer made what was termed "accelerators" to enrich the weak and almost unburnable gas into a good gasoline gas.

The "accelerators" consisted of a wide-mouthed heavy glass bottle with a two-hole rubber-stopper fitted. The bottle would hold, when full, about a pint of gasoline. The rubber stopper was fitted with two pieces of glass tubing bent at right angles at their upper extremity, to fit into the gas hose.

One glass tube was about 6 in. in length and led the weak gas from the line down into the bottle to the surface of the gasoline, the other tube was just long enough to reach through the rubber stopper and carried the enriched gas through a short length of gas tubing to the burner. The bottle if filled with gasoline in the morning would enrich the gas for a half day or so. The object of having the one piece of glass tube longer than the other was to make it possible to follow the surface of the gasoline down into the bottle as it was evaporated. This also furnished a means of regulating the amount of the enrichment the weak gas received. A bulb was blown in the glass tube leaving the "accelerator" in which glass wool was inserted to prevent the flame following back into the bottle from the burner on turning the gas off. One of these accelerators was made for each burner used.

It was noted on using these "accelerators" that the more volatile and lighter constituents evaporated first and left a heavier portion behind in the bottle which amounted to from 50 to 60 per cent of the original volume of the gasoline. This residuum very much resembled kerosene in appearance but would not burn when poured on the cement floor. It could be completely vaporized, however, if warmed to the boiling point by setting the "accelerator" in hot water or on a radiator. Ordinarily in using the "accelerator" when 40 to 50 per cent of the gasoline had evaporated the remainder was thrown out and more gasoline was put in.

These "accelerators" have been in use about three months and have proved a valuable accessory to an independent gasoline gas plant.

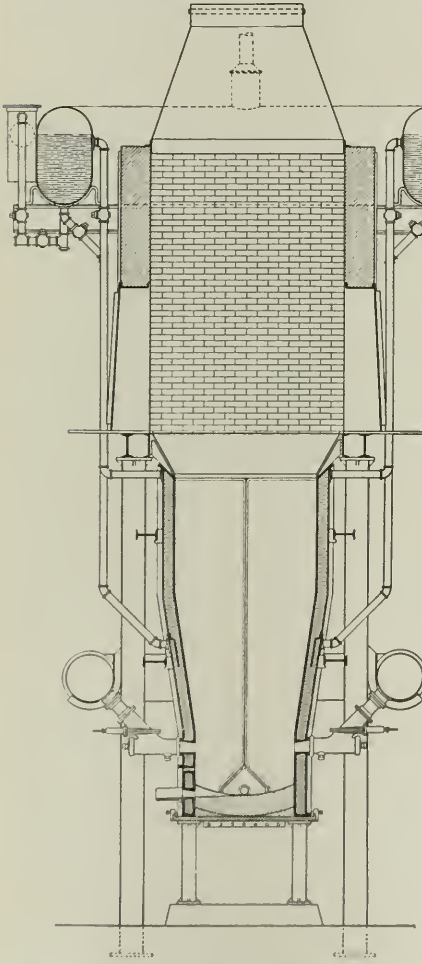
---

The **Munning-Loeb Co.**, of Matawan, N. J., have just issued Bulletin 500 on their line of plating and industrial brushes. The book contains information on brush manufacture from the making of the block, selection and origin of stock to the final finish. Operating characteristics of the several brush materials and their adaptability to certain classes of work are briefly discussed.

## The Vaporization of Jacket Water

Catalog No. 12-F, just issued by the Colorado Iron Works Co., of Denver, Colorado, and entitled "Some Details as to Smelting Practice and Equipments," contains an exceedingly interesting chapter on the Vaporization of Jacket Water, which deserves the full attention even of experienced smelting men. We herewith reproduce this chapter practically in full.

In many localities the matter of jacket water supply is a very serious one, either from absolute scarcity, expense of pumping, or cost, where it has to be purchased. This led the Colorado Iron Works to a serious study of the problem, and their solution of it, the Nesmith patented system of vaporization, not only reduces the amount required to one-eighth of that ordinarily necessary, but also provides what experience has proved to be the best method of cooling even where water is abundant.



NESMITH PATENT JACKET WATER VAPORIZER

Some smelter operators run so much water through their jackets that it is discharged at a temperature much below the boiling point. Their reason for this is primarily to obviate the close attention otherwise necessary and they also think that they are on the safe side and that the cooler jackets are run, the better. This is a mistaken idea. Aside from the fact that an important loss of heat, which must be compensated for by additional fuel, results from such practice, the life of the jackets is much greater when they are run with the discharge as near the boiling point as possible. Both cast iron and steel have greater tensile strength and a higher elastic limit at 400 degrees Fahrenheit than at lower temperatures, and the hotter jackets can be kept, the more durable they will be. More cast-iron jackets are broken and steel jackets damaged by running an excess of cold water through them than in any other way. The sudden admission of cold water to a cast-iron jacket which has been running hot is especially liable to cause its failure.

As indicated by its name, the principle upon which this system is based is to take advantage of the latent heat of vaporization of water. The magnitude of the saving thus effected is plainly apparent in the following figures.

The heat absorbed by one pound of water at 212 degrees F. in passing into steam is 966 British thermal units, the application of this amount of heat being necessary to produce the change from liquid to gaseous state. In cooling jackets in the ordinary manner, the heat units carried off by the water equal the number of degrees difference in temperature between the feed and discharge, and assuming the feed water temperature to be 62 degrees and the discharge 212 degress, the maximum possible heat abstraction of one pound of water is 150 units.

If now the pound of water be completely vaporized, there will be 966 units added to the 150 units, or a total of 1,116 units of heat utilized. This shows the amount of water necessary when vaporized to be, $150 \div 1116 = 0.1344$ or 13.44 per cent. of that necessary where the water is discharged as water at the boiling point. The results in actual practice are better than this, for the discharge of the water at the boiling point has been assumed, and this is a condition which is never even closely approached, owing to the danger of supplying insufficient water.

The water obviously can not be boiled in the jackets, but our system provides means whereby full advantage is taken of the latent heat of vaporization without danger of overheating any jacket—in fact, with absolute assurance of all jackets being continuously and evenly cooled.

The vaporizing system operates in a manner similar to the hot-water system ordinarily installed in residences, in which the water back in the range corresponds to the water jackets of the blast furnace. The arrangement of piping is similar and circulation of the water is maintained in the same way.

For use with this system the jackets are the same as with the ordinary overflow system except that the pipe connections are larger in order to reduce friction The pipes lead to a closed drum surrounding the furnace, the feed pipes being connected to the bottom and the discharge pipes entering the drum slightly below the water level. The tendency of the hot water to rise and cold water to find the lowest level maintains a very effective circulation and any boiling takes place in the drum, not in the jackets, because the water in the jackets is under sufficient head to cause the boiling point to be several degrees higher than in the drum which is only under atmospheric pressure. A gauge glass indicates the water level, an automatic float valve controls the admission of water to replace that evaporated, and a vapor escape pipe provided with an exhaust head conducts the steam formed to the atmosphere.

A smelter superintendent, after operating a furnace provided with this vaporization system for several months, recently gave the following information on jacket water consumption:

"The furnace proper is using about 90 gallons per hour. I have not had time to figure this back to gallons per square foot of jacket area, but as the jacket area on this furnace is large, it should show a very low water consumption per square foot. * * * It is without question the best water system for a blast furnace I have ever seen. All jackets are always at a uniform temperature; with a proper float valve absolutely no attention is required. In blowing-in we never think of the water, while with the old-style overflow system it generally keeps one man busy to keep from burning a jacket. In places where water is scarce a more elaborate condenser on the exhaust head would save nearly all the water. Another very good feature is the fact that different furnace men have their own ideas about jacket water—one wants to run his water cool or cold and another hot with no two jackets the same, while with this system it absolutely cuts out the 'personal element' and the jackets must have a decided benefit from the constant temperature."

Jacket water consumption is usually determined in gallons per minute, to avoid large figures, but as is evident from the above quotation, gallons per hour would be a more convenient measure of comparison were the vaporizer system in universal use. However, on the customary basis, the exposed jacketed surface of the above furnace being 414 square feet, the water consumption was 0.00362 gallon per minute per square foot of jacket area. This was a copper matting furnace. Another user of the vaporizer system, operating a lead furnace, reported a water consumption of 0.0113 gallon per minute per square foot jacket area, but this vaporizer was run without an automatic float valve and loss of some water was consequently unavoidable.

Comparison of the above with published figures for Cananea, 0.616, and for Granby, 0.31, shows an actual saving far above the theoretical, and brings out strongly the magnitude of the waste of water in cooling jackets in the ordinary way. At Granby, the discharge from the upper jackets was the feed for the lower jackets, which accounts for the large economy shown over Cananea, the amount of water used at Cananea being about what is ordinarily required.

The jacket water is commonly run into settling ponds where it is cooled and reused, but there is great loss from evaporation and seepage, to say nothing of the expense of pumping. The installation of the vaporizing system will cost less than settling ponds and it entails no continual expense, as for pumping. In addition, it provides cooling means in every way superior to the ordinary overflow method.

---

**Radium Prices.**—At the Senate hearing on radium Mr. Thomas F. V. Curran, of Placerville, Colo., who is engaged in mining and shipping carnotite ores, stated that he sold his product to Armet de Lisle, Nogent sur Marne, France, where he obtained the best prices. Payment is made on the basis of hydrous radium bromide, $RaBr_2.2H_2O$, delivered, at the rate of 100 francs ($19.30) per milligram per ton, for ore containing from 6 mg to 10 mg per ton; over 10 mg per ton a bonus of 20 per cent is paid. As the ore contains from 3 mg to 4 mg $RaBr_2.2H_2O$ per ton, the price received ranges from $60 to $80 per ton of ore. Mr. W. L. Cummings, another shipper from Placerville, stated that he was paid $2 per pound for the uranium oxide contained, f.o.b. Placerville. On 2 per cent ore, which is average shipping grade, the price would come to $80 per ton.

## Electric Furnace Regulator

In the interesting American Electrochemical Society paper of Mr. Robert Turnbull, of Welland, Ontario, Canada, noticed on page 333 of our May issue, a number of important principal advantages were mentioned which can be obtained in electric furnace operation by the use of nearly all kinds of regulators.

Among special advantages which may be derived from the use of the Thury regulator, Mr. Turnbull mentioned the following:

1. The damping devices employed only permit the regulator to act, when it is necessary for it to do so. Sudden changes and changes of short duration will not put the regulator in action. This in itself is very important, as not only is there a great saving on the wear and tear of the electrode hoisting mechanism, motors for driving same, etc., but the current is kept more uniform by avoiding the regulation of such changes.

2. This regulator can handle any amount of power for regulating purposes, without in any way impeding the free play of the controlling mechanism, which is only in contact with the power mechanism for exceedingly short periods of time and is otherwise perfectly free.

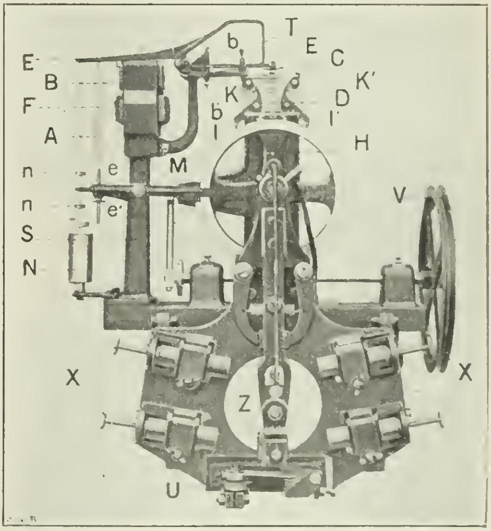


FIG. 1—THURY REGULATOR

3. The regulator requires no attention whatever, and with the exception of the oiling of the moving parts once a week, can be practically ignored.

4. Great variations of current can be automatically obtained by use of this regulator.

5. The intermittent action of the contact-making arm is important, as the regulation is thereby prevented from being carried too far in one direction and a high load factor is assured at all times and uniform current on the furnace.

The Thury regulator is the invention of Mr. R. Thury, of Geneva, Switzerland. It was first applied to electric furnaces in 1901 by Dr. Paul Heroult to his first steel furnace:

The principal parts of the regulator (Fig. 1) are the fixed coil F, the movable coil B, the rocking lever E, the spiral spring A, the dashpot or damping device

N, the abutment knives C, the tappets K, the pawls I, the tappet wheel H, the copper contacts Z, the carbon contacts, and the short-circuiting device U.

When the current operating the furnace is at its normal value, the rocking lever E is held in equilibrium by the pull of the spring A, and the magnetic force of the fixed coil F acting on the movable coil B. The knives fixed to the rocking lever in this position swing clear of the tappets K. When a variation of sufficient duration occurs on the furnace, the movable coil will either be pulled to or pushed away from the fixed coil, depending on whether the current has decreased or increased on the furnace, and the rocking lever will swing either the one or the other of the knives against one of the tappets K. The tappet is pushed from its position, releases the pawl I which falls into the notch in the tappet wheel. The arm carrying the copper contacts, which is fixed to the tappet wheel shaft, will swing either to the right or to the left, bringing the copper contacts against the carbons, and current will immediately flow to the terminals of the winch motor.

The Cuenod Company of Geneva, Switzerland, who now control the manufacture of the Thury regulator, have added to the regulator a series of apparatus, which taken together form a very complete regulator system. This system can best be described by a reference to Fig. 2.

It consists of the following:

1. A winch T R for raising and lowering the electrodes.

2. A double-throw switch with carbon contacts CR, worked by an automatic Thury regulator R, which starts, stops, and reverses the motor MT as desired.

3. An adjustable resistance RA, permitting a modification of the current on the furnace, for instance, from 2000 to 10,000 amperes, by steps of 1000 amperes.

4. A controller CM for hand and automatic control.

5. A current transformer T, operating the solenoid of the regulator.

One cycle of operation in this system would be as follows:

We will suppose that the current flowing through the secondary bars to the furnace is above the normal. The current flowing from the secondaries of the transformer T to the solenoid of the regulator, will also be above normal, and the increased magnetic force will push the movable coil against the pull of the spring until the knife C will encounter the tappet K, pushing the latter out of its position, thereby releasing the pawl I. This pawl falls into the notch in the tappet wheel H which in turn brings the copper contacts Z on the lever, in contact with the carbon contacts, and the current immediately flows to the winch motor through the controller CM. When the current on the furnace has been brought back to its normal value, the regulator will cease to act and the lever carrying the copper contacts will remain in its central position, until again called upon to act, through a variation of current in the furnace.

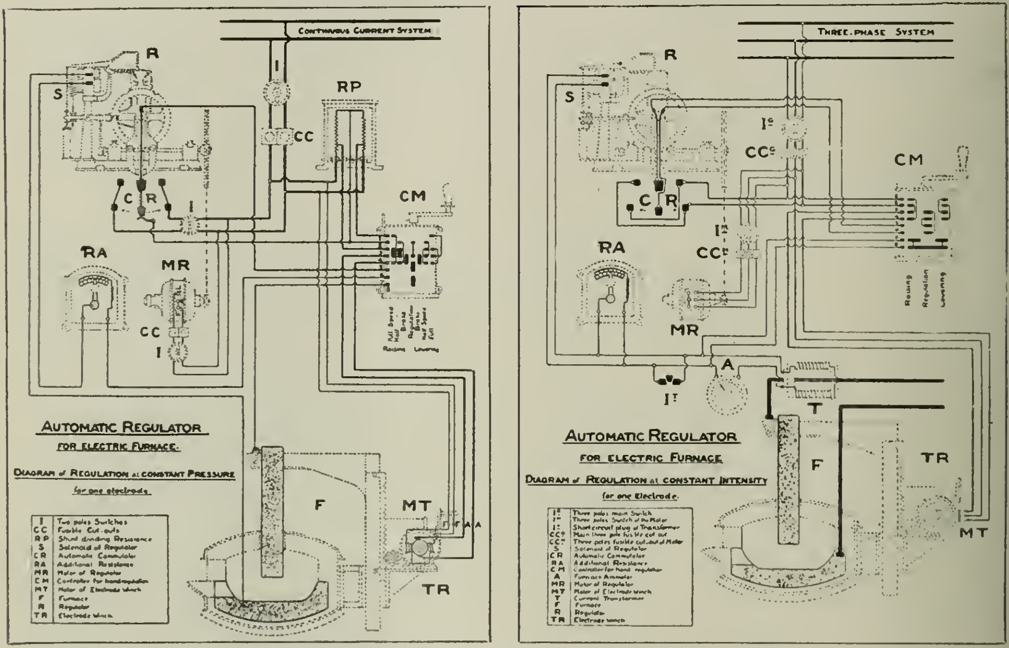


FIG. 2—AUTOMATIC REGULATOR SYSTEM FOR ELECTRIC FURNACES

---

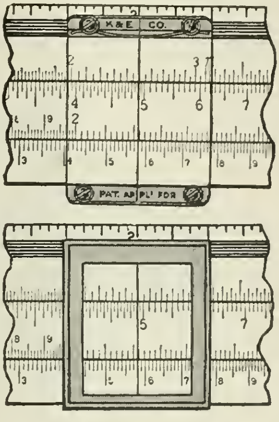
**The mineral output of California** for the years 1905 and 1912, with comparative estimate for 1913, is shown in the table below, compiled by F. McN. Hamilton, State Mineralogist:

| Substance | 1905 | 1912 | 1913 |
|---|---|---|---|
| Petroleum | $9,007,820 | $41,868,344 | $46,000,000 |
| Gold | 19,197,043 | 19,713,478 | 20,000,000 |
| Cement | 1,791,916 | 6,074,661 | 8,000,000 |
| Copper | 2,650,605 | 5,638,049 | 5,500,000 |
| Crushed rock and granite | 2,070,607 | 5,473,928 | 6,000,000 |
| Brick | 2,273,786 | 2,940,290 | 3,000,000 |
| Borax | 1,019,158 | 1,122,713 | 1,250,000 |
| Natural gas | 102,479 | 940,076 | 1,250,000 |
| Silver | 678,494 | 799,584 | 800,000 |
| Quicksilver | 886,081 | 866,024 | 700,000 |
| Other minerals including asphalt, clay, lead, marble, mineral earths, salt, tungsten, zinc, etc. | 3,391,238 | 6,035,238 | 7,500,000 |
| Totals | $43,069,227 | $91,472,385 | $100,000,000 |

## The Latest Slide Rule Improvement

A new patented indicator or runner for slide rules, called the "frameless," has just been perfected by Keuffel & Esser Company. Every figure on the rule is clearly visible at all times, there being no side pieces to the metal holder of the glass indicator, and therefore, nothing to hide any of the figures on the rule (see Fig. 1). This is one of the most important improvements in slide rules.

Many times, after setting the old-style indicator or runner, the user would find that he could not read the result because important figures were hidden by the frame or holder of the glass (Fig. 2). Frequently two, and sometimes, four or even six, eight or nine figures would be thus hidden; causing more or less inconvenience and uncertainty in reading the slide rule. The new "frameless" indicator or runner entirely obviates this difficulty.



FIGS. 1 AND 2—SLIDE-RULE INDICATOR—NEW STYLE, UPPER PICTURE; OLD STYLE, LOWER PICTURE

Thousands of engineers and scientists in every profession and industry, as well as contractors, builders, architects and merchants have found the slide rule invaluable as a time and brain saver in quickly and accurately making a great variety of calculations. In its various forms, it has been adapted by Keuffel & Esser Company to the needs of practically every line of work, including all branches of engineering, as well as chemistry. A new slide rule, especially adapted to the needs of the chemist, was described in our March issue, page 201.

## Compressing Air and Gases

One matter more than anything else has held back the introduction of compressed air for many industrial purposes. This has been the cost of compressing the air. The first cost of the compressor itself is high. Moreover, expensive foundations must be installed. Then the compressor and the receiver occupy much valuable floor space. The services of an experienced engineer are required to operate it. Taking all this together, it is clear that the overhead expense is a big item and becomes especially serious where the air is only required intermittently. Further, the power is an important consideration. All this explains why managers of industrial plants have been hesitating to introduce compressed air for purposes for which it would have been otherwise very useful.

A decisive advance has been made by the Nash Engineering Company, of South Norwalk, Conn., in the design of the Nash hydroturbine. These pumps are capable of delivering air or gas at 15 lb. pressure on continuous twenty-four-hour service with absolute reliability and high efficiency and it would seem that the Nash hydroturbine, because of its simplicity, low first cost, and low installation expense, small space occupied, absolute reliability and high efficiency, opens up a large field for the use of compressed air.

There is no longer any necessity of having long lines of air piping, with big losses due to leakage and air friction. A small Nash compressor, belted off a line shaft or direct connected to an electric motor can be located at the place the air is used, and started up by the operator of the machine when wanted.

Heretofore it has been the usual practice, where some of the work required high-pressure air, to install a compressor giving a pressure of 60 to 100 lb. and reduce the air needed at low pressure by throttling or by means of a reducing valve. Oftentimes 75 per cent of the work in the plant can be handled with entire satisfaction with a pressure not exceeding 10 to 15 lb. It is needless to say that there is no economy in compressing air to 100 lb. and then reducing it to 15 lb. for use.

The Nash hydroturbine offers a practical solution of this problem. A hydroturbine is installed of a capacity sufficient for the entire plant for both high and low-pressure air. This pump is arranged to maintain a pressure of 10 to 15 lb., depending upon the pressure required for the bulk of the work in the plant. If some air is required at 60 to 100 lb., a small compressor is installed, taking its air from the delivery side of the Nash hydroturbine and boosting it to the desired pressure. The compressor for the high-pressure air will be small, only one-half to one-eighth the size that would otherwise be necessary, the size depending on the amount of high-pressure air required.

The space occupied will be less. There will also be a saving in power, both for the high-pressure air, as well as the low-pressure air, because the Nash hydroturbine is very efficient. The air is used at the pressure to which it is compressed, and two-stage compression is used for the high-pressure air. The compression in the Nash is isothermal, therefore no intercooler is required.

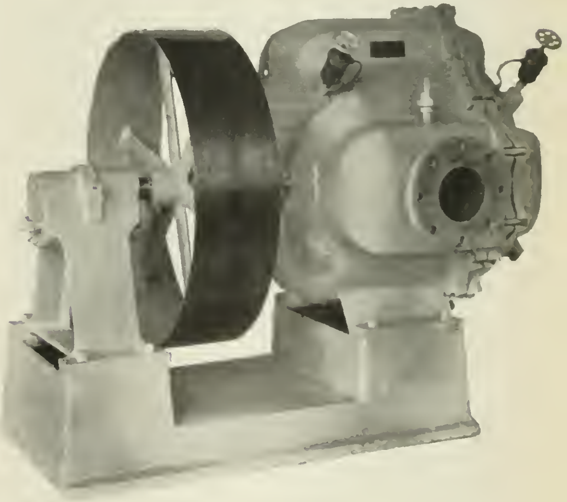


FIG. 1—HYDROTURBINE

The Nash Engineering Company, the exclusive manufacturers of air compressors and vacuum pumps working on the hydroturbine principle, have been building these pumps for about four years. Fig. 1 shows the latest single-stage design of their hydroturbine. It differs from the first pumps put on the market only in minor details, such as the additional outboard bearing, position of the outlet and inlet piping, etc.

The extreme simplicity of the pump is best illustrated by Fig. 2, wherein all the principal parts are shown. The case, head and wheel constitute the pump.

Fig. 3 is a cross-section showing the principle of operation. The pump consists of a casing and a head, surrounding a wheel with projecting blades, which is rigidly mounted on a shaft, supported by bearings in the head and casing. The casing is elliptical in section. The rotor, the periphery of which is a true circle, clears the short diameter of the elliptical casing by 1-16 in. to 3/32 in., depending upon the size of the pump, so that there is no possibility of the blades striking, even if the bearings become worn.

Above and below the narrow part of the ellipse, ports are cut through the casing, and similar ports are cut through the head, exactly opposite. These communicate with cored passages, connected to the inlet and outlet pipes.

Water, or other liquid, is introduced into the pump. The rotor is revolved by power applied to the shaft, carrying the water with it. The water, however, follows the casing due to centrifugal force.

This means that twice in a revolution it recedes from and surges back into the rotor, due to the elliptical form of the case. As the water goes out of the rotor it draws air in through the ports to fill its place. This air is carried around with the rotor, and is compressed and delivered through the outlet ports by the re-entering water. Each half of this elliptical case is really a separate pump. As the outlet and inlet ports are diametrically opposite, the pressures on the rotor, due to compression, are exactly balanced, thus relieving the bearings of all side-pressure.

Since the blades of the rotor are passing the outlet ports continuously, the air is delivered without pulsation.

The blades of the rotor are reinforced by two shrouds, as will be seen in Fig. 2, leaving just enough space between the hub to register with the ports. The steel shaft is a drive fit in the rotor, and is fastened securely by two pins going clear through the interior hub and shaft.

The shaft is supported by three bearings, one each in the head and casing, and one forming the outboard bearing. The pump and outboard bearings are dowelled to the case, and the head flange is recessed and fitted to the casing, so that exact alignment will be preserved if the pump is taken apart and reassembled.

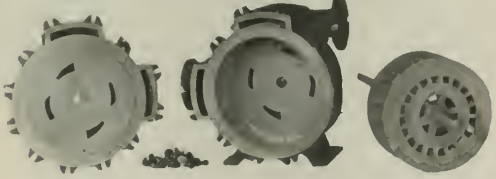


FIG. 2—CONSTRUCTION OF HYDROTURBINE

The bearing bushings are made of best grade of babbitt, containing about 85 per cent. tin. They are fitted so that they can be tapped in with a light mallet, and are prevented from turning by means of a lug cast in the bushing, which fits in a recess in the containing casting.

The outboard bearing is ring-oiled. The bearings in the head and casing are lubricated with graphite grease, as this is more reliable than oil in the presence of water. The grease is fed to the bearings by means of compression cups of special design, located near the top of the pump. The air pressure is admitted to the top of these cups to balance the pressure, so that the grease will flow to the bearings readily.

The outlet and inlet pipes are equipped with standard flanges. The design is such that the head can be removed and the rotor taken out without disturbing the piping.

All parts of the pump are made absolutely interchangeable.

It is apparent from the above that there is nothing about these pumps to get out of order. In fact, they are practically indestructible with any reasonable care. In addition to being absolutely reliable, they are very efficient, occupying small space, and are quiet in operation. They are so simple that anybody can operate them. All that is necessary is to keep them supplied with lubricant.

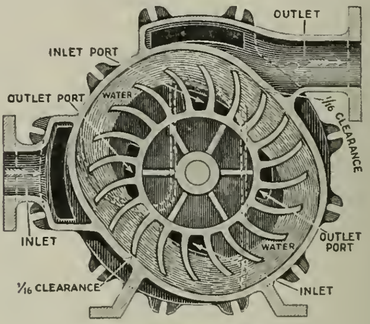


FIG. 3—PRINCIPLE OF OPERATION OF HYDROTURBINE

The standard pumps such as used for compressing air are made of cast iron. Where mild acid gas is to be handled, sufficient protection can be secured by keeping the contained water slightly alkali. Where the particular conditions of the plant would result in the corrosion of the cast iron the pumps are made of any other suitable metal or alloy.

While we have described in the above the use of the Nash hydroturbine for compressing air or gases it may be added that it is also a powerful and efficient vacuum pump.

---

**Monel metal**, the natural copper-nickel alloy, is finding a wide variety of uses, among which is the manufacture of non-corrodible window screen cloth.

**American Ingot Iron in England.**—The American Rolling Mill Company of Middletown and Zanesville, manufacturers of American ingot iron, have invaded England by closing up two contracts under which the Shelton Iron, Steel & Coal Company, of Stoke-on-Trent, and Richard Johnson & Nephew, Ltd., of Manchester, secure the right of using the American Rolling Mill Company's method. The capacity of the American works of the latter company has increased from 40,000 tons of sheet in 1906 to 166,000 tons at present.

**Large Metal Value in Utah.**—The value of the mine output of gold, silver, copper, lead and zinc in Utah in 1913 was $44,858,210, compared with $42,922,302 in 1912, according to Victor C. Heikes, of the United States Geological Survey. The production of gold was valued at $3,565,229, a decrease of $700,622, or 16.42 per cent, compared with 1912. The largest producer of gold was Salt Lake County, which yielded $1,777,214, against $1,788,730 in 1912. The West Mountain or Bingham district, in Salt Lake County, produced $1,774,815, or 49.78 per cent of the total output. The Tintic district, in Juab and Utah Counties, ranked first in gold output in 1912, but was second in 1913, with $1,412,462, or 39.61 per cent of the total.

## Prospects of Electric Zinc Smelting in British Columbia

From the *Daily News* of Nelson, B. C., we learn that there is an excellent chance of the Johnson electric zinc furnace being tried out on a commercial scale in Nelson or Trail, British Columbia. As the Johnson furnace and process are so well known to our readers, we simply report that a party consisting of Messrs. Byron E. Eldred, W. McA. Johnson and James Struthers, all of New York, and A. E. Barlow, of Montreal, visited Nelson and Trail on May 4, 5, 6 and looked carefully over the ground.

The plan is for the erection of a ten-ton furnace plant at a cost of $75,000, and the Nelson Board of Trade passed unanimously a resolution:

"That the Board favor and support the proposal that a grant be made by the Dominion government to the Johnson Electric Smelting, Inc., of $25,000 on completion by them of a demonstration plant of 10-ton capacity in West Kootenay ready for operation, and a second government grant of $25,000 upon a successful commercial demonstration of the operation of same by a continuous thirty-day run under the oversight and to the satisfaction of a representative of the government."

## Digest of Electrochemical U. S. Patents

PRIOR TO 1903.

*Arranged according to subject-matter and in chronological order.*

*Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.*

*Electroplating* (Continued)

175,134, March 21, 1876, Charles S. Minchew, of Taunton, Mass., assignor to Reed & Barton, of same place.

Relates to electroplating, especially upon soft metals, such as britannia ware, with other metals, and calls the process "impulsio-plating." The article is first made chemically clean by boiling in caustic alkali, then mechanically cleaned with sand, brushes and water. It is then wired in running water. It is then connected as cathode in a hot alkaline solution of oxalate of soda and a strong current passed. It is then quickly transferred to the plating-bath and the desired deposit made in a hot solution under pneumatic pressure. After the deposit, the article is washed and dried, and then subjected to a temperature of 180 deg. F., which is said to "drive in" the deposit.

215,463, May 20, 1879, Nathaniel S. Keith, of Brooklyn, N. Y.

Relates to the electrolysis of lead and increases the conductivity of the electrolytes by adding to solutions of lead salts, similar salts of more electropositive metals, such as of sodium, magnesium, aluminium, etc. The more nearly saturated, the higher is the conductivity.

273,467, March 6, 1883, Alexander Classen, of Aachen, Germany.

Relates to electroplating from solutions of oxalates, which are made as follows: to solutions of chlorides or sulphates of the metals to be plated are added solutions of potassium or ammonium oxalate to form double salts; ammonium oxalate is then added in excess to the hot solution, and later a small quantity of sodium carbonate may be added. For nickel, the following proportions are given: five hundred grams nickel sulphate and eight hundred grams of ammonium oxalate are dissolved in ten liters of water. The deposit is made from a heated solution, using an anode of carbon or platinum.

300,035, June 10, 1884, William Henry Walenn, of Islington, county of Middlesex, England.

Relates to electroplating copper, etc., at temperatures near the boiling-points of the solutions, in closed vessels, the solution being under pressure of about one atmosphere, or less. For copper, an electrolyte is made as follows: thirty-two ounces, avoirdupois, of cyanide of potassium, and one ounce of neutral tartrate of ammonium are dissolved and diluted to one imperial gallon. The solution is then charged with copper from an anode until about three ounces per gallon is dissolved, using a large anode and small cathode. To this solution is added ammonia cupric oxide, until the solution turns slightly green in color. The ammonia cupric oxide is made by adding caustic potash to copper sulphate, boiling the solution, removing the precipitate and dissolving it in strong ammonia water of 0.880 specific gravity, to saturation. The deposits of copper are said to be adhesive and ductile, and not to separate when the plated sheets are hammered, etc.

330,149, November 10, 1885, Gaston Pilet and Clément Carry, of Besançon, France.

Relates to electroplating palladium, and describes an electrolyte made of chloride of palladium containing ten grams of metal; five liters of water; one hundred grams of phosphate of ammonium; five hundred grams of phosphate of sodium; ten grams of benzoic acid, which may be omitted, but is said to bleach the deposit, and renders the deposit more striking upon iron or steel. The bath may be used cold to produce a steel color deposit; if heated to from 40 deg. C.-50 deg. C., the color is whiter. A feeble current is preferred. Another electrolyte is also described.

331,104, November 24, 1885, William H. Winslow, of Brooklyn, N. Y.

Relates to electroplating articles with iron, and then converting the iron coating into magnetic oxide. An electrolyte containing twenty parts of salammoniac to one hundred parts of water is electrolyzed with two wrought iron plates for anode and cathode. After the electrolyte is suitably charged with iron, the cathode is removed and the article to be plated inserted. The plating must be carefully conducted; about one hour's time being considered sufficient. The iron-coated article is then removed and heated in an atmosphere of superheated steam in a muffle at about 1000 deg. F. to 1200 deg. F. for from five to seven minutes, which converts the iron coating into magnetic oxide. It is said to have a steel-bluish-black color, hard, non-corrosive and very attractive in appearance. Refers to a copending application which became patent No. 331,105.

331,105, November 24, 1885, William H. Winslow.

Relates to articles having a coating of magnetic oxide of iron, produced by the process described in his copending application which became patent No. 331,104. The patent describes the production of an electrotype having a magnetic oxide of iron printing face.

## Personal

Mr. Lawrence Addicks has resigned as superintendent of the Chrome, N. J., refinery of the U. S. Metals Refining Company, and is now in Douglas, Ariz., in an advisory capacity, to study the possibilities of leaching at the various Phelps Dodge properties and direct the large-scale experiments under way at present at Douglas.

Mr. E. L. Messler, formerly with the Jones & Laughlin Steel Company, as general superintendent of their Pittsburgh coke ovens, blast furnaces and ingot mold foundry, and for the past two years as assistant to the president of Riter-Conley Manufacturing Company, is no longer associated with the latter firm He has as yet not decided what line of work he will follow. Mr. Messler's present address is care of the Duquesne Club, Pittsburgh, Pa.

**Mr. William P. Baer**, formerly of the Sprague Electric Works of the General Electric Company, has joined the forces of the Trumbull Electric Mfg. Co., and will represent them in part of the Middle West and also a part of the Southern territory.

**Mr. George H. Garrey** has severed his connection with the American Smelting & Refining Co., and allied companies, as their chief geologist, and has opened an office as consulting mining geologist and engineer at 115 Broadway, New York.

**Mr. W. R. Hulbert**, of the Goldschmidt Thermit Company of New York, presented recently a fascinating lecture on thermit and its latest developments in railway shop practice before the Railway Club of Pittsburgh. The paper is printed with illustrations, together with the extended discussion which followed, in Vol. 13, No. 3, of the official *Proceedings* of the Railway Club of Pittsburgh.

**Mr. Henry E. Jacoby** announces the removal on May 1 of his offices to larger and more spacious quarters at 95 and 97 Liberty Street, where he will continue to specialize on chemical machinery and equipment of all kinds, including a much larger and more improved line of vacuum drying apparatus.

**Mr. J. B. Mendenhall**, formerly with the National Lead Company, is now southern representative of the Great Western Smelting & Refining Company.

**Mr. J. Malcolm Muir**, business manager of *Metallurgical and Chemical Engineering*, was married on May 14th to Miss **Lida C. Kelly** in Louisville, Ky. Mr. and Mrs. Muir are now enjoying a honeymoon in the sunny South, somewhere in the Blue Ridge Mountains.

**Dr. Joseph Struthers**, formerly secretary of the American Institute of Mining Engineers and editor of Mineral Industry, has accepted the office of second vice-president of the Johnson Electric Smelting, Inc., controlling the American rights of the Johnson electrothermic process for the treatment of zinc ores and zinciferous lead and copper ores, with offices at 18 East Forty-first Street, New York City.

**Mr. W. P. Thornton**, who has been with the Riter-Conley Mfg. Co. for many years in various capacities, has resigned to accept a position with the Treadwell Construction Co. During the erection of the eight Gary blast furnaces of the United States Steel Corporation he was the engineer in charge for the Riter-Conley Company.

**Mr. Alois von Isakovics**, of Monticello, N. Y., lectured on May 8 before the Institute of Arts and Sciences and the Senior Organic Students of Columbia University on "perfumes and flavors, their chemistry, synthesis and practical application." He was introduced by Professor M. T. Bogert and after the lecture a vote of thanks was extended to Mr. von Isakovics on motion of Dr. C. F. Chandler.

## Obituary

**Herman Frasch** died on May 1 at his home in Paris at the age of sixty-two. Herman Frasch was born in a small town near Stuttgart, Wuerttemberg, the son of the burgomaster of the town. Leaving the gymnasium at Halle, at the age of sixteen, he apprenticed himself for a time to a pharmacist. He came to the United States in 1868 and found his first employment in the laboratory of Prof. John M. Maisch at the Philadelphia College of Pharmacy. A little later he established a laboratory of his own, in which he made his first invention of importance, completed in 1876 a new process for refining paraffin wax. This he sold to a subsidiary of the Standard Oil Company. In 1885 he bought an oil field in Canada, started the Empire Oil Company, and soon invented the process for eliminating the sulphur which before that time had prevented the use of the oil for illuminating purposes. This invention was purchased by the Standard Oil Company, whose chief chemist Frasch then became. After serving as chief chemist of the Standard Oil Company for over twenty years, Frasch turned his attention to extracting sulphur from the beds underneath the marshes of Louisiana. This was accomplished by sinking shafts down to the bed through which the sulphur was melted by superheated steam and forced up by the pressure generated. This novel industry is in the hands of the Union Sulphur Company, of which Frasch was president. In 1912 the Perkin Medal was awarded to Herman Frasch by the Perkin Medal Committee, consisting of representatives of the Society of Chemical Industry, the American Chemical Society and the American Electrochemical Society. A report of the proceedings at the presentations of the Perkin Medal to Herman Frasch will be found in our issue of February, 1912, which contains a full account of his life and his lifework.

* * *

Dr. Walter Feld, a prominent German gas engineer, died on March 15th. Among his most notable inventions is a centrifugal gas washer for the purification and cooling of blast-furnace and producer gases, for the recovery of metal dust from gases of lead and copper smelting plants, for the extraction of tar from coke-oven gases, etc. A very interesting new process of Dr. Feld relates to the extraction of ammonia and hydrogen sulphide from coal gases and the direct production of ammonium sulphate therefrom without the use of sulphuric acid. Two interesting articles by Dr. Feld on these subjects appeared on pages 395 and 436 of our volume X (1912).

## Book Review

**The Copper Handbook.** A Manual of the Copper Mining Industry of the World. By **Walter Harvey Weed.** Vol. XI., 1912-13. Price $5. Houghton, Mich.: Walter Harvey Weed, 1914.

Under the able editorship of Horace Jared Stevens, the Copper Handbook had grown from a modest book of 300 pages, covering Michigan mines, till the tenth edition (1910-11) had become a manual of the copper industry of the world and a volume of 1902 pages. It had become recognized authority and its account of the doings of the copper mining companies was accepted as impartial and fearless when Stevens died on April 12, 1912.

Fortunately his untimely death did not mean the end of the Copper Handbook. It was acquired by Mr. Walter Harvey Weed a year after Stevens' death and the eleventh volume has just been issued. It may be said to be fully up to the standard set by its founder.

The first part (989 pages) gives detailed notes on all copper mines in North America, alphabetically arranged, and is followed in the second part (39 pages) by a very useful geographical index in which the mines are grouped by countries, states, counties, and mining districts. Part III. (285 pages) gives detailed notes on foreign companies. Part IV. (47 pages) contains statistics and part V. (53 pages) a list of dead mining companies.

"As in former editions, any gold, silver and lead mines producing copper as a byproduct has been included, practically making the book a mining manual, at least for America." As a reference book, in the arrangement of its contents, the present volume shows considerable improvement over former editions.

# Metallurgical and Chemical Engineering

A Consolidation of ELECTROCHEMICAL AND METALLURGICAL INDUSTRY and IRON AND STEEL MAGAZINE

VOL. XII NEW YORK, JULY, 1914 No. 7

PUBLISHED MONTHLY BY THE
McGraw Publishing Company, Inc.
JAMES H. MCGRAW, President.
C. E. WHITTLESEY, Secretary.
JOHN T. DE MOTT, Treasurer.
239 West 39th Street, New York.
TELEPHONE CALL, 4700 BRYANT.
CABLE ADDRESS, METCHEM, NEW YORK.

ROCKY MOUNTAIN OFFICE........421 Boston Bldg., Denver, Colo.
PACIFIC COAST OFFICE......502 Rialto Bldg., San Francisco, Cal.
CHICAGO OFFICE..........................Old Colony Building
PHILADELPHIA OFFICE................Real Estate Trust Building
LONDON OFFICE............Hastings House, Norfolk St., Strand

E. F. ROEBER, PH.D., Editor.
H. C. PARMELEE, Western Editor.

J. M. MUIR, Manager.

*Yearly subscription price for United States, Mexico and United States dependencies,* **$2.00;** *for all other countries,* **$2.50.** *(European exchange,* **10** *shillings,* **10** *marks,* **12.50** *francs.)*

Copyright, 1914, by the McGraw Publishing Company, Inc.

Entered as Second-Class Matter at the Post Office at New York, N. Y., under the Act of Congress, March 3, 1879.

NEW YORK, JULY, 1914

EDITORIAL:

The First Chandler Lecture........ 427
The Cost of Noise........ 427
Welfare Work in the Steel Industry........ 428
Industrial Peace and Professional Ethics........ 428
Craft, Cunning and Intelligence........ 429

READERS' VIEWS AND COMMENTS:

Rapid Evaporation of Solution in the Determination of Silica and Alumina in Iron Ores. By W. S. Wurtzel.. 430
Is There a Complex Ore Problem? By Parker C. Choate 430
Definition of Alloys. By C. J. Thatcher........ 430
The Western Metallurgical Field........ 431
The Iron and Steel Market........ 433
The Non-Ferrous Metal Market........ 434
Troy Meeting of American Institute of Chemical Engineers.. 434
Ninth International Congress of Applied Chemistry........ 435
Paris Meeting of British Iron and Steel Institute........ 436
A Mine at the San Francisco Exposition, 1915........ 436
Some Professional Obligations. By M. C. Whitaker........ 437
Physical Versus Chemical Action in Furnaces. By Carl Hering........ 439
Electrolytic Refining of the Precious Metals. By H. Lacroix.. 441
Superheated Steam and Railway Locomotives........ 443
Electric Iron Smelting at Hardanger in Norway. By John Harden........ 444
First Chandler Foundation Lecture........ 446
Chemical and Industrial Applications of Mechanical Refrigeration. By H. J. Mcintire........ 447
Copper in Scotland........ 448
Notes on Unit Cost-Keeping in Metallurgical Work. By Justin H. Haynes........ 449
The Construction of the Blast Furnace Stack. By J. E. Johnston, Jr........ 451
Colorimetric Estimation of Gold in Cyanide Solution........ 460
Three Metal Bronzes. By Allmand M. Blow........ 461
Notes and Observations on Ore Treatment at Cobalt, Ontario, Canada. By H. C. Parmelee........ 467
The Story of Mining and Metallurgy. By T. A. Rickard.... 469
Is There a Complex Ore Problem? Contributions by F. L. Clerc and L. D. Godshall, and Editorial Summary........ 471
The Application of Physical Chemistry to Industrial Processes. By Walter F. Rittman........ 475
RECENT CHEMICAL AND METALLURGICAL PATENTS........ 479
SYNOPSIS OF CHEMICAL AND METALLURGICAL LITERATURE..... 480
An Economic Way to Handle Shipments of Long Iron Rods.. 482
Filter Press Experience in a Cuban Sugar Plant........ 482
Electric Annealing Furnace for Brass and German Silver Ware........ 483
PERSONAL........ 485
DIGEST OF ELECTROCHEMICAL U. S. PATENTS (Electroplating). 485
BOOK REVIEWS........ 486

## The First Chandler Lecture

The celebration of the fiftieth anniversary of the Columbia School of Mines was the occasion of a wonderful outpour of love and affection for its only surviving founder, the dean of chemistry in America, Dr. Charles F. Chandler. It was the psychological moment for the fitting inauguration of the lectureship which is to commemorate forever Chandler's name at Columbia. And as Dr. Baekeland was the lecturer, it goes without saying that the first Chandler lecture was brilliant and worthy of the occasion.

Under these conditions our apologies would be due to our readers for not publishing in full Dr. Baekeland's lecture in this issue, if it was not for a remarkable clause in the Chandler Foundation to the effect that the Chandler lecture is first to be published in the official "Quarterly" of the School of Mines, which may mean a delay of a month or two. Of course, such a clause, like any attempt to put a release date on any speech made in public, is absurd. It can be legally enforced only if the Chandler lectures are to be star chamber proceedings. Is this the intention? Or is it a suggestion that watchful waiting is a good preparation for prospective readers of Chandler lectures? Or it is an attempt to cripple live technical newspapers in favor of their slower brethren? We can't conceive of any sensible reason, if widest publicity is really desired for the Chandler lectures. Or is the reason psychological? Was it simply a case of Homer nodding?

## The Cost of Noise

In a recent conversation the superintendent of a large stamp mill made the observation that "noise costs money." We had been discussing the use of stamps as crushing machines and the comparative merits of various devices for crushing ore. One of the arguments advanced by this superintendent against the use of stamps was the tremendous and never ending noise produced by the falling weights. In his opinion the din was responsible for many misunderstood directions and orders to employees, resulting in confusion, loss of time, and expensive mistakes. The point is readily perceived. The average mill employee is anxious to give the impression that he understands the boss's orders, and rather than ask a question for further information he will sometimes pretend to understand and then go and seek advice from a fellow workman. The order may be wrongly executed or not at all. The noise of the stamps contributes greatly to this condition, makes it difficult to give and receive orders, and undoubtedly causes many mistakes. The cost of noise may not be estimated exactly, but it is a real factor.

## Welfare Work in the Steel Industry

Eleven years ago, when the annual scale settlement was made between the Amalgamated Association of Iron, Steel and Tin Workers and the union tin plate mills, the only change made in the scale was the adoption of the following paragraph: "That the company furnish ice or well water to its employees." Considering the nature of the work at the hot mills the demand of the men, thus complied with, was certainly a very modest one.

The incident gives us a viewpoint. When barely over a decade ago it required the demand of a fairly strong labor organization to secure suitable drinking water for men whose occupation required them in summer to drink water not by the quart but by the gallon per turn, it is doubtful whether we are able, without such checks, to realize the sweeping character of the welfare work which has been in progress in recent years in the steel industry.

Again, if we do realize the extent of the work which is going on there is a possibility of misjudging the influences which cause it. Our London contemporary, the *Iron and Coal Trades Review*, for instance, with what is almost a covert sneer, suggests that the United States Steel Corporation, recognized as the greatest leader in this work, is defending a suit by the government for its dissolution under the Sherman anti-trust law. Who could prove his ground for an assertion that it is because the Steel Corporation has been under fire that it has undertaken these things? That it is because the corporation is very large that it has done so much is, on the other hand, a statement which can be supported by much circumstantial evidence. Among the "independent" steel manufacturers, for instance, it is commonly found that the larger the concern, the more welfare work has been done. There is ground, in the existing facts, for formulating a general principle that the larger the manufacturing interest the more likely it is to adopt comprehensive plans for improving the working and home conditions of its employees. The work has been principally of a pioneer nature and large interests are more able to do such work than small interests. When practices have become well established the difficulties in the way of the smaller interests are removed.

Welfare work, including mill sanitation, establishment of hospital departments, beautifying mill surroundings, provision of rest places, protection against accidents, playgrounds for employees' children, encouragement of home gardening and the like, are already yielding tangible and direct results. There is no question that "they pay." There is little danger of making mistakes. The various efforts that have been put forth have almost invariably been strikingly successful, and this is a greater proof of the propriety of the work than is generally recognized.

Compare, if one will, the failure of so many systems of profit sharing. Welfare work as we know it is much less than a decade old. Profit sharing is many decades old, and yet with all the experience gained the failures have been so many that the question may well be raised to-day whether there is any known system of profit sharing which can be guaranteed to give adequate results.

Certainly there are very recent instances of absurdly inadvisable methods, the most glaring doubtless being that of the famous "car" builder of Detroit. It is the greatest possible tribute to welfare work that it has been so signally successful in its very earliest years when after decades of experiments so theoretically desirable a principle as profit sharing cannot yet be carried out with anything like similar success.

## Industrial Peace and Professional Ethics

The last graduating class of the Colorado School of Mines was honored at the commencement exercises by an address from Dr. Rossiter W. Raymond, whose subject was "Professional Ethics." Filled with excellent advice on a phase of professional life too often neglected, the address came as a fitting close to four years of absorbing application to technical studies, as well as a practical introduction to an honorable engineering career.

The ethical principles of life are simple in formula, and well known to all educated men; but their consistent application to life seems difficult on account of the complexity and multiplicity of human relations. Thus, unless studiously avoided, morality among men may come to be a relative matter of training, experience and interpretation of principles, often leading to perverted reasoning and resulting in the acceptance of misleading half-truths, such as "the end justifies the means." Comparing man's relations in war and peace, Dr. Raymond finds that the recognized elements of warfare have been adopted in business. Speaking of war he says that "perhaps its greatest evil result is its corruption of the ways and habits of peace." Certainly industrial peace is coming to be recognized as a desideratum far above the success that is coincident with, and dependent upon, acts of warfare and piracy in business. Hence the need for "honesty, justice and fair play," which are accepted among us as the principles of ethics.

Touching directly on the ethics of engineers, chemists, and metallurgists, Dr. Raymond outlined some of the obligations which are imposed on men in those professions: as authors, as employees, as factors in business transactions and as advisors.

The ethics of authorship, either of reports or papers, demand that the writer shall not pretend to knowledge that he does not possess or ability that he has not acquired. Authorship implies a contract on the part of the writer to present clearly and logically to the mind of the reader those things to which he makes legitimate pretense of knowledge. He is not justified in creating a false impression to gain personal ends, nor in appropriating as his own the language of others.

As an employee an engineer must possess and display the quality of loyalty as well as ability. This is "dictated by honor, and even by selfish interest." How rare is the employee who shows the same devotion to his work that is felt by his employer. Ability counts for little in personal equipment if it is not supported by loyal devotion. "The time is past when the master could watch all the details"; and with the development of vast enterprises involving the co-operation of many men, the demand for loyalty is greater than ever before.

As a business agent the engineer must act in perfect faith and maintain his integrity unquestioned. The secret commission on purchase of property or equipment is one of the most insidious forms of temptation to forget or neglect the interest of a client. Secret acts sooner or later come to light, and usually at a time when explanations are difficult or impossible.

In advising clients on professional matters the engineer must be free to tell the whole truth, not suppressing any pertinent facts. His reports should be made in such a manner that they cannot be misconstrued or garbled by unscrupulous persons. In giving expert testimony in litigation he should not take the witness stand unless he has examined the case and believes that he can be of service to his client; nor should he serve his client for money to the detriment of his own good name and reputation.

The spirit of the time demands fair play and a square deal. The engineer must be frank, open and above board in all his dealings, and must preserve his integrity by avoiding complications that may arise from the disclosure of secret acts. With the speaker at Golden we may say, "Do not do what you could not tell without shame," and likewise ask, "Why not walk in the light?"

## Craft, Cunning, and Intelligence

Words like metals have varying uses. Meanings like metals are of different degrees of purity. It can be laid down as an axiom that the word intelligence has the meaning in its broadest sense that connotes the ability to see and remember things with the result of being able to accurately foresee the future. If one will examine life and foresee the common use of the word "intelligence" he will see that people usually mean just about that and nothing more, the ability to foresee the future, even though the future may be immediate. For instance, if a man were walking by an office building where a safe was being hoisted up and he crossed to the other side of the street we would call him cautious or prudent, but we would basically mean that he was intelligent. Man is a sentient creature, but he is distinguished from other creatures also sentient, such as animals because he has intelligence and it is by use of intelligence that he has arisen from savagery and has conquered nature.

The word intelligence can be used in a concrete sense or it can be used in an abstract sense. We can look to the effects of intelligence to understand it or we can understand it directly by subjective powers.

Probably all the ills of individual and state are caused by a lack of full intelligence. And in a narrower sense intelligence of the higher type can be differentiated from intelligence of a lower type, i.e craft or cunning. Craft is a word originally used objectively to denote the power of "doing something." Cunning derived from anglo-saxon word cognate with "can," likewise means ability "to do something."

Nowadays both these words—craft and cunning—suggest the ability "to do somebody." So it is in the disinclination of people to see the practical and efficacious difference between intelligence and craft that is the cause of what can be vaguely described as vague social unrest. It is plain that if the public frowned on or ostracised men that wrecked railroads to amass money by craft and cunning such men would cease to exist. But the public has had always a sneaking admiration for such men. The public kicks at the trusts, but in the past fifteen years have given ear with eagerness to the accounts in magazines and newspapers of the intimate life and pursuit of happiness of the individuals who have grown rich out of the trusts. It would seem to follow that the public is to blame in this respect and did not really know itself.

The word intelligence, however, has a broader, higher and nobler application. A man who grows rich by building up a railroad, does good rather than harm and he has gained his power by true intelligence, rather than by craft or cunning. The three words, craft, cunning and intelligence, have also a social application. Intelligence operates to benefit society, craft to hurt it. Intelligence sees clearly and works for its own good in part, but in larger part for the good of the community. It attains its unselfish ends, possibly with a selfish motive, but at least with altruistic effects. Craft or cunning simply looks to its own immediate good. By their fruits we must know them.

For instance, a rat is foxy because it escapes the trap and "gets away" with the cheese and a fox is ratty because it steals a chicken without being caught. From its own standpoint, a rat and a fox are eminently intelligent and unqualifiedly respectable—does not a rat wear dignified side whiskers and does not a fox brush himself daily?—but from the standpoint of man they are asocial agents and anti-social. Accordingly a foxy business man or a ratty politician—oily, slick articles—are asocial because each merely thinks of himself from the viewpoint of society each is not intelligent but cunning. It all depends on the viewpoint.

Now, if society could and would discriminate between intelligence on one side and craft or cunning on the other side, if the rewards were given for real work, not for results of "getting by" or "getting away with it" or "slipping something over," expressions of the vernacular so suspiciously frequent as to almost postulate their universal acceptance as true doctrine—we would have fewer lawyers and more good ones, real leaders of religious thought rather than ecclesiastical charlatans, statesmen—not mere politicians or demagogues, fewer militant suffragettes and more pleasing women, happy tillers of the soil instead of bad farmers, and the cost of living would go down.

# Readers' Views and Comments

## Rapid Evaporation of Solution in the Determination of Silica and Alumina in Iron Ores

*To the Editor of Metallurgical & Chemical Engineering:*

Sir:—In the estimation of silica and alumina by the method of fusion with sodium carbonate, every chemist is confronted with the problem of evaporating the solution in the shortest possible time. The water-bath is practically excluded on account of the long time required, and the operation usually is conducted in an evaporating dish placed directly on the hot-plate and covered with a large watch-glass. The drawbacks to this procedure are evident to all who have to do such work; there is too great a risk of loss by bumping, spattering, and overheating.

In order to obviate these difficulties, the writer has made use of the following device which has proved very satisfactory. Make a ring of sheet tin, $\frac{3}{4}$ in. high and $4\frac{3}{8}$ in. in diameter. This is suitable for use with an evaporating dish $5\frac{1}{2}$ in. in diameter; other dimensions can be used for dishes of various sizes. The ring is placed directly on the hot-plate and used as a support for the evaporating dish. No cover is required. With a ring and dish of dimensions given above, the bottom of the dish will not touch the hot-plate, and we have, in effect a hot-air bath on which evaporation will proceed under the boiling point of the solution. All of the vapors can escape readily, not being retained by or condensed on a watch-glass cover.

While the evaporation is proceeding the operator is at liberty to dispose of his time as desired until a point is reached where the residue appears just moist or damp. The dish should then be removed to a cooler place to prevent any loss by decrepitation of the chlorides, but as soon as no more vapors escape and the residue appears dry, it is safe to complete the dehydration on the hottest spot of the plate.

The advantages accruing to this method of evaporation are: The dish is more easily handled and cools more quickly when removed from the plate; the residue appears more homogeneous; no crust has to be washed from a cover; less solution has to be filtered, and the volume of the filtrate for the final determination of alumina is small. The operation requires less time.

S. Wurzel.

Sunrise, Wyo.

## Is There a Complex Ore Problem?*

*To the Editor of Metallurgical and Chemical Engineering:*

Sir:—(1) Re: the "complex ore problem"; any ore is complex that will not show a profit when treated by the commonly known and developed metallurgical methods. All ores carry more than one possible value, and many a large number, and thus as industrial uses arise the complexity of commercially converting nature multiplies and the end is infinity.

(2) The presence of zinc "blende" in a form that is not amenable to mechanical separation is the usual reason for the word "complex." It most certainly is not the fault of the present methods in metallurgy or lack of skilled operators, but entirely the lack of commercial methods and application.

(3) In a broad sense we are not utilizing half the value that our non-complex ores show us because the balance is uncommercial under the imposed condition, while there are innumerable examples of very large tonnage carrying heavy gross values that are not treated because uncommercial. Value is a vague term to use, as it may be interpreted to mean the metal value of the ore as gross, or net, and again, might be figured as the value of compounds of metals or constituents manufactured directly from ores.

(4) As applied to present practised metallurgical methods the presence of zinc "blende" existing with other sulphide is the most usual refractory element, but baryta, arsenic, or even other elements might render the ore uncommercial or complex.

(5) There will be no universal process that will solve the complex ore problem because it is not a universal problem. Roasting and slag smelting has had its day, but will be limited to ores where heavy values are not carried off in slags. Electric smelting will supplant much present cupola and reverberatory practice.

Mechanical dressing will always pay up to a point where waste does not defeat it. Processes for preparing ores for the pyrometallurgical process, other than mechanical, will play a part. Leaching and chlorination processes are clearly the best methods in many instances. Volatilization methods as steps in complete treatments or direct treatment for commercial separation of values are sure to become very prominent. Electrometallurgy as applied in refining, distilling, producing reactions now impractical, will fill voids not now realized by many.

(6) Microscopic examination would belong to the laboratory department to determine the nature of the ore; the treatment used must be governed solely by the commercial aspects. There is rapidly coming a revolution in metallurgy due to technical education, and progress lies in the hands of the inventor or research agent coupled with financial support to commercialize his creation.

Parker C. Choate.

National Lead Company,
Brooklyn, N. Y.

## Definition of Alloys

*To the Editor of Metallurgical and Chemical Engineering:*

Sir:—In your April issue, page 218, you quoted the decision of His Honor, Judge Hough, in the suit on the Welsbach patent, No. 827,017, for a Cerium Pyrophoric alloy, and which decision contains the statement: "The important words (for this case) are *two or more metals*, and all the experts examined agree that an alloy must contain that number."

Since the well informed readers of your journal know this definition to be incorrect, allow me to state that the Court erred in stating that *all* of the experts thus incorrectly defined the scope of the term alloy. In my own expert deposition in this suit, when the definition quoted by the Court was called to my attention in Q. 40, I replied: "an alloy may be formed by combining or mixing a metal with some *non-metallic* solid elements so as to form a solid coherent product." And, as I stated in my answer to xQ. 42, my opinion was confirmed by one of the opposing experts, who also described "such a manner of making an alloy—a *pyrophoric* alloy—of *cerium* and silicon."

Chas. J. Thatcher.

New York City.

---

*Mr. Choate's interesting communication was received after the communications by Messrs. Clerc and Godshall and the editorial summary which will be found on page 471 of this issue, had already been set in type and arranged in page form. Mr Choate's communication is, therefore, printed separately at this place.—Editor.

## The Western Metallurgical Field

### Chlorination at Park City, Utah

The chlorination mill of the Mines Operating Co. at Park City Utah, has been running steadily for several months at a capacity of about 165 tons of ore per day. During March 5000 tons of ore were treated from which 7 tons of precipitate were produced for shipment. The plant is reported to be operating at a profit. Filling from the Ontario stopes is being treated. This ore contains 9 to 10 oz. silver and 0.03 oz. gold per ton, 0.05 per cent. copper, 1.0 per cent. lead and about 1.0 per cent. sulphur. With the ore crushed to $\frac{3}{8}$-in. size the saving is 80 per cent. of the silver, 90 per cent. of the copper and 30 per cent. of the gold. Some lead is also extracted but practically nothing is realized on it when shipped to the smelter. When crushing to 8-mesh, 90 per cent. of the silver can be saved.

This process consists essentially of crushing the ore to $\frac{3}{8}$-in. size, chloridizing-roasting with salt, leaching with acid and salt solution, and precipitating the silver, copper, gold and lead on scrap iron. The ore first passes through a trommel with 1-inch openings, the oversize going to a gyratory crusher and the undersize to a stationary dryer. Seven per cent. salt and 2.8 per cent. coal dust are then mixed with the ore by feeding these materials from their respective bins on to a common belt conveyor. The ore, salt and coal dust mixture is crushed in rolls to pass a $\frac{3}{8}$-in. trommel, and stored in bins over the roasters. Chloridizing-roasting is performed in 6 vertical blast-roasters, each of about 35 tons daily capacity. After roasting is completed, side doors at the base of a roaster are opened, and the hot ore is sluiced out of the furnace with weak, acid, mill-solution into a wooden leaching tank of which there are six. After settling for about 3 hours, the solution is drawn off through the bottom of the tank to the precipitation boxes. Barren solution is then turned on the tank for from 20 to 24 hours, passing to the weak solution tank for use in sluicing out the roasters. The tanks are then sluiced out with water. There are two series of precipitation boxes containing all kinds and grades of scrap iron. Silver is precipitated in the front boxes, followed by copper, with a predominance of lead in the last boxes. There is no marked dividing line in this precipitation as all the metals come down in all parts of the boxes, but there is sufficient distinction to be noted by the eye.

A novel feature of the plant is the type of roaster employed. It consists of a vertical shaft of square horizontal cross-section, with grate-bars in the bottom to support the ore, beneath which the air blast is introduced. The roasters are built of brick or concrete and lined with cement so as to give a smooth vertical wall. Wooden grate-bars are used, which are covered with about 4 in. of coarse and crushed ore to protect them from the heat. As they are wet by the solution in sluicing out the roaster and protected by the covering they have no great tendency to burn, especially with the blast driving the heat up and away from them.

The roaster is of intermittent operation as at present constructed. After a charge has been removed, the 4-in. covering over the wooden grates is stirred up by the laborers to prevent caking. A small amount of coal dust moistened with coal oil is then spread over the floor of the roaster. This is ignited, a little ore shoveled in through the side doors, and then after closing the doors the furnace is charged to a depth of about 6 feet with the ore, salt and coal dust mixture from the ore chutes above the furnace. Charging and roasting take about 16 hours and discharging or sluicing about 6 hours. An experimental 9-ton roaster has shown the possibility of modifying the furnace for continuous operation by the use of steel grates arranged so as to partly discharge the furnace when moved horizontally for a short distance. This roaster is always filled with ore. When the roast is complete, the grates are operated mechanically to lower the ore in the shaft about 18 in., when more of the mixture is charged at the top. Discharging in this manner is done about every $1\frac{1}{2}$ to 2 hours, taking not over 5 minutes. This furnace has considerably reduced the necessary labor.

The leaching solution used in this plant is barren mill solution from the precipitation boxes to which sulphuric acid is added in the barren solution tank. It contains from 3 to 4 per cent. of hydrochloric and sulphuric acids and as high as 20 per cent. salt. About 70 lb. of 60° B. sulphuric acid is added per 24 hours, or at the rate of about 0.42 lb. per ton of ore. Some bleaching powder is added in the leaching tanks, about 20 lb. per tank, to assist the solution of the gold. No difficulty has been experienced with fouling of solutions due to presence of iron. The solution does not contain over 2 to 3 per cent. iron. The precipitate from this solution contains 4,000 to 10,000 oz. silver and 1 to 5 oz. gold per ton, 30 to 40 per cent. copper and 10 to 25 per cent. lead. The scrap iron consumption is one ton of iron to a ton of precipitate.

The process employed at this mill appears to be working satisfactorily for the extraction of copper and silver from this low grade material. Wooden tanks and pipes, and air lifts are used for handling the acid solution. No more apparent difficulty is experienced with this solution than with ordinary cyanide solution. Wooden valves were used at first, but rubber hose and clamps are now installed and give better satisfaction. Materials are stated to cost laid down at the mill as follows: Coal dust, $1.75 per ton; salt, $4.45 per ton, and sulphuric acid, 1 cent per pound. As the smelter does not pay full value for the silver in the precipitate, a refinery would be added if a new plant were constructed. The silver and gold in solution would then be precipitated on copper, and the copper and lead on iron, thus producing a gold-silver bullion and blister copper.

### Company Reports

From the annual reports for 1913 of four of the large copper companies the following tabulation of data is prepared:

| | Chino | Ray | Nevada | Utah |
|---|---|---|---|---|
| Ore milled, tons...... | 1,942,700 | 2,365,296 | 3,139,137 | 7,519,392 |
| Copper content %.... | 2.033 | 1.719 | 1.599 | 1.247 |
| Conc. produced, tons.. | 183,117 | ...... | 452,233 | ...... |
| Copper content, %.... | 14.518 | 18.550 | 7.61 | 17.31 |
| Ratio concentration... | 10.61 | .... | 6.94 | .... |
| Percentage recovery.. | 67.31 | 66.09 | 68.52 | 63.95 |
| Milling cost, c. per ton | 61.08 | 51.93 | .... | 36.76 |
| Cost copper, c. per lb.. | 8.787 | 9.784 | 9.99 | 9.498 |
| Ore reserves, tons.... | 90,000,000 | 78,380,966 | 39,108,590 | 332,500,000 |
| Copper content, %.... | 1.8 | 2.2 | 1.65 | 1.47 |

The operation of the Chino plant during the last seven months of the year clearly demonstrated an average mill capacity in excess of 6,000 tons per day. No additions of consequence were made to the mill except in the coarse crushing plant, where another crusher and set of rolls were provided to insure against delays. The low ratio of concentration was due to the high iron content of ore from certain parts of the mine, resulting in an abnormally large tonnage of concentrates and an increased cost in transportation and smelting. The installation of a plant for recleaning concentrate has improved this condition.

All of the eight sections of the Ray Consolidated mill have been completed and are ready for operation as needed. Some important changes made in the flowsheet last year has enabled the management to increase the tonnage handled and at the same time improve the metallurgical results. The slightly increased cost of milling was due to intermittent operation during the progress of construction. There has been a marked decrease in accidents at mine and mill, which the company attributes to its "safety first" campaign. A school of instruction for the avoidance of accidents, mine rescue and first-aid work is maintained, and prizes are offered to employees suggesting the best safety appliances.

The increased cost of copper production at the Nevada Consolidated was due to the lower ratio of concentration which resulted in increased smelting cost. An increase in wages also added 0.394 cents per pound of copper produced. Replacements and betterments were responsible for an increase of 0.19 cents per pound of copper. Many improvements were made in the concentrator in 1913, resulting in improved settling of slime and recovery of water, improved concentration and classification. At the Steptoe smelter the roasting plant was enlarged by the addition of two furnaces. In the reverberatory department there has been an increase in capacity of furnaces from 262 tons charge in 1911 to 371 in 1912 and 481 in 1913. The longer furnaces have not shown a reduction in oil ratio but show better costs.

**The Utah Copper Co.** completed in 1913 the alterations in the coarse crushing departments at both the Magna and Arthur mills. During the year when running on low-grade ore, the Magna plant demonstrated its ability to handle nearly 14,000 tons daily, and the Arthur mill over 10,000 tons. This gives an aggregate capacity of 24,000 tons daily for very low-grade ore. With material of average grade the economic capacity of the mills is about 21,000 tons per day. A decreased percentage of recovery is noted, due to the lower average grade of ore treated. The total cost of mining, transportation and milling was but $0.9761.

From the seventh annual report of the **La Rose Consolidated Mines Co.**, Cobalt, Canada, we take the following data referring to operations for 1913. The company produces high-grade ore for direct shipment, and low-grade rock for concentration by the Northern Customs Concentrator.

SHIPMENTS

| | Dry tons | Oz. silver per ton | Per cent of total net value |
|---|---|---|---|
| Silver-Cobalt-nickel ore.... | 1,275.8 | 1,500.8 | 75.7 |
| Low-grade silicious ore.... | 1,076.5 | 112.5 | 3.4 |
| Nuggets .................. | 6.1 | 22,658.1 | 5.9 |
| Concentrates ............ | 915.9 | 456.6 | 15.0 |
| Totals and average...... | 3,274.3 | 791.8 | 100.0 |

COST OF PRODUCING SILVER

| | Per ton ore | Per oz. silver |
|---|---|---|
| Mine operation ............ | $117.23 | $0.1474 |
| Concentration ............. | 30.90 | .0388 |
| Marketing ores ............ | 48.96 | .0616 |
| Depreciation .............. | 3.57 | .0045 |
| Corporation and traveling.... | .66 | .0008 |
| | $201.32 | $0.2531 |
| Less rents, interest and discounts ............... | 19.96 | .0251 |
| Total cost production.... | $181.36 | $0.2280 |

Cost of production amounted to 38.62 per cent of gross value of ore produced.

CONCENTRATION

| | |
|---|---|
| Ore milled, tons.......................... | 37,556 |
| Silver content, oz. silver per ton............ | 13.53 |
| Concentrates produced, tons............... | 950.11 |
| Silver content, oz. silver per ton........... | 460 |
| Cost of milling, dollars per ton........... | 2.73 |
| Average tonnage for 313 days............ | 120 |
| Ratio of concentration.................. | 39.5 |

The picking and jigging plants at the mines produced 292,886 oz. silver in jig concentrates which was added to the high-grade ore. The rock on the dumps at mines amounts to 91,857 tons, estimated to contain about 15 oz. silver per ton.

**The Anaconda Copper Mining Co.** reports on its operations for 1913 as follows: Severe weather in January and February, 1913, caused a diminution in the quantity of ore treated, and this, combined with the necessity of a shut-down at the Washoe smelter in October for the purpose of cleaning flues, resulted in a lessened output of refined copper for the year, as well as an increased cost for the same. The company's mines produced 4,644,201 tons of ore and 7243 tons of precipitates. The reduction works treated 4,016,689 tons of ore and cupriferous material at Anaconda, and 1,170,150 tons at Great Falls. Production at these plants was as follows:

| | Copper, lb. | Silver, oz. | Gold, oz. |
|---|---|---|---|
| Anaconda ........ | 205,730,594 | 9,026,690 | 53,935 |
| Great Falls ...... | 64,571,050 | 1,294,606 | 10,964 |

The experimental work on slime concentration has been finished and plans have been adopted. Centrifugal concentration has been abandoned in favor of treatment on round tables. A plant of 2,000 tons daily capacity is under construction, comprising a slime dewatering plant of 160 Dorr thickeners, a round-table plant of twenty round tables of twenty decks each, and a concentrate dewatering plant of five Dorr thickeners. It is expected that this equipment will be ready for operation this summer, and will produce about 300 tons of concentrates daily, yielding about 1,000,000 pounds of copper per month at a very low cost. Experimental work with the 80-ton sand-leaching plant was successful, and there is now under construction a 2,000-ton plant. Further experimentation has been authorized on slime tailings. Coal-dust firing of reverberatories is under trial, following an investigation of this practice at different places in this country and Canada. The reconstruction of the smelting plant at Great Falls is progressing nicely. It is the intention to abandon the concentration of ore at Great Falls, doing all this work at Anaconda and shipping concentrates to Great Falls for smelting.

**The American Zinc, Lead & Smelting Co.** reports that in 1913 the zinc industry was in an extremely unsatisfactory state, and as a result of unfavorable conditions the company sustained a loss from operations amounting to $91,656. This was augmented by other items, including one dividend of $85,600, to a total loss, charged against surplus, of $304,630. The physical condition of the company's smelters and other plants is good, and with a return to normal conditions in the zinc industry will be able to show substantial earnings. The new smelter at Hillsboro has made no profit, owing largely to starting under the unfavorable conditions mentioned. The Tennessee property is proving highly satisfactory, an important feature being that the tailings from the mines can be used for railroad ballast, road construction, concrete work and roofing material. The fine slime can be sold for limeing the soil of farms in Tennessee and surrounding states. This disposal of tailings may expand to such an extent as to amortize a large part of the original cost of property and equipment.

The eighth annual report of the **United States Smelting, Refining & Mining Co.** shows the following production of metals in 1913:

| | | Per cent of total value | Average price received |
|---|---|---|---|
| Copper .... | 20,239,973 lb. | 18.8 | $0.15433 per lb. |
| Lead ...... | 58,116,504 lb. | 15.3 | .04396 per lb. |
| Silver ..... | 13,089,708 oz. | 47.3 | .60503 per oz. |
| Gold ...... | 148,372 oz. | 18.6 | |

Net earnings for the year amounted to $3,585,586, and dividends totalled $2,755,466. The report of the exploration department shows that the company was tendered 614 properties during the year, of which 190 were rejected on office examination of reports and data submitted. A preliminary field examination was made of 100, and a complete examination and sampling of 24 was undertaken. Three groups of claims were bought: the Last Chance, adjoining company property at Bingham, Utah; La Reunion group connecting the Real del Monte and Pachuca properties in Mexico, and the Spread Eagle group in Shasta county, California.

## The Iron and Steel Market

For the first time since January there has been a definite and important improvement in the iron and steel market. Beginning approximately with the first of June pig iron buying increased and the volume of steel orders improved.

In pig iron the movement was largely seasonal in that the contracts of consumers began to run out and as prices were attractively low there was a disposition to cover for third quarter requirements.

In steel there had been only desultory buying for several months. While buyers probably accumulated some stocks as a result of the January buying movement, in April and May they followed a steadfast policy of reducing stocks to the utmost.

Orders for prompt shipment of steel products booked in June probably averaged between 25 and 40 per cent more than the corresponding bookings in May, which was easily the poorest month in this respect since December. It did not follow that production and shipments increased in like measure, because some of the shipments in May were the result of earlier commitments and some increase in buying was necessary merely in order that buyers should continue to receive as much material as formerly. There was, however, an excess, whereby mill shipments have probably averaged a somewhat larger tonnage in the past month than in May.

While buying for prompt shipment increased, a disposition appeared to buy for forward delivery. There had previously been scarcely any forward buying. The disposition to buy for forward delivery was partly seasonal, but it represented in larger part a recognition that prices for steel products were extremely low. In March, for instance, there was no disposition to buy for second quarter shipment as a whole, because prices had advanced not long before and were then showing a declining tendency.

With bars, plates and shapes available at 1.10c. black sheets at 1.80c. and galvanized sheets at 2.75c., all for prompt shipment, buyers began to negotiate for third quarter contracts at these figures. In practically all instances the mills quoted higher prices, by $1 or $2 a ton, and the third quarter business closed has been chiefly at advances of about a dollar a ton over what could be done for immediate shipment.

The present prices are extremely low relative to the cost of production. It will be recalled that a very low point was reached in November, 1911, the lowest average since early in 1899, when conditions were so different that reasonable comparisons cannot possibly be made. The average price of finished steel products to-day is not as much as a dollar a ton above the low level of two and a half years ago. At that time the mills made practically no money. Since then the general wage level has been advanced and with mills operating at a lower rate than then their cost of production is automatically increased.

The June improvement in buying is not in itself of much significance. Early in April it began to be said that steel market conditions had become so bad that there could be no change except an improvement. The June movement in itself has not been as pronounced as was that of last January, and yet that movement played out, leaving no lasting effect. The present movement is lesser in degree and if it is similar in kind it gives no particular promise. In some quarters it is maintained that this is the beginning of a long and important movement and that the market will not soon again see such stagnation as characterized April and May. The test of the theory will come quickly. July is normally a very dull month, and if the market resists its soporific influence it will prove that there are still better things to come month by month.

The United States Steel Corporation's unfilled orders decreased 376,757 tons in April and 278,908 tons in May, leaving the unfilled tonnage at the beginning of June 3 998,160 tons, of which tonnage it is to be presumed only a relatively small proportion was for shipment within the month. Conditions in June have been such that there is a prospect that the report to be made public July 10 will show an increase for the month in the unfilled tonnage.

Steel production and shipments during June have been at fully 60 per cent of the entire mill capacity, showing no important change from May. In July many mills will close for repairs and shipments are not at all likely to increase.

Car buying was slightly heavier in June than in May. In the first half of the year fully 60,000 freight cars were ordered and this is really a fairly good showing considering what drastic policies of retrenchment are in force with the railroads.

### Pig Iron

Early in June the leading cast iron pipe interest purchased 67,000 tons of Southern pig iron for second half delivery, while export orders for about 40,000 tons of Southern iron were closed at about the same time. The business developed a lower market price in Southern iron by 25 cents a ton, but at the same time greatly increased interest in the pig iron market in general. It is normal for Southern iron to lead the general pig iron market, in both upward and downward movements. Buying of pig iron has since been more general in all districts, though the movement is by no means as pronounced as was that of a year ago when conditions in pig iron were more or less similar to those of the present. Production of pig iron has been at the rate of about 24,000,000 tons a year in June, comparing with the maximum rate of this year of 28,000,000 tons, reached in March and April, and a record high rate of 34,000,000 tons, reached in February, 1913. The market is quotable as follows: No. 2 foundry, f.o.b. Birmingham, $10.25; delivered Philadelphia, $14.50 to $14.75; f.o.b. furnace, Buffalo, $12.75 to $13; f.o.b. furnace, Chicago, $13.50 to $14; at valley furnaces (90 cents higher delivered Pittsburgh) No. 2 foundry, $13; basic, $13; malleable, $13 to $13.25; gray forge, $12.50 to $12.75; Bessemer, $14.

### Steel

As a rule, consumers of billets and sheet bars did not absorb their full contract tonnages in the second quarter and with considerable tonnages being carried over July 1 they have been slow to negotiate fresh contracts. While little has occurred to develop actual market prices it is recognized that the market is quotable at about $19.50 for billets and $20.50 for sheet bars, f.o.b. makers' mill, Pittsburgh or Youngstown, these prices being 50 cents a ton below the nominal figures named a month ago.

Rods can be had at $25, mill, or $1 a ton below the quotation of a month ago.

### Finished Steel

Prices quoted below show a slight decline, on the whole, during the month. They are for prompt shipment, contracts covering a period of three months usually bringing about $1 a ton more. Quotations are f.o.b. Pittsburgh, unless otherwise noted:

Rails, standard sections, 1.25c. for Bessemer, 1.34c. for open-hearth, f.o.b. mill, except Colorado.

Plates, tank quality, 1.10c.

Steel bars, 1.10c., base.

Shapes, 1.10c.

Iron bars, 1.25c., Pittsburgh; 1.22½c., Philadelphia; 1.05c., Chicago.

Sheets, blue annealed, 10 gage, 1.30c.; black, 28 gage, 1.80c.; galvanized, 28 gage, 2.75c.; painted corrugated, 28 gage, 2.00c.; galvanized corrugated, 28 gage, 2.80c.

Steel pipe, ¾ to 3-in., 80 per cent off list.

Steel boiler tubes, 3½ to 4½ in., 72 per cent off list.

Standard railroad spikes, 1.40c., Pittsburgh; 1.50c., Chicago.

Structural rivets, 1.55c.

Boiler rivets, 1.65c.

Cold rolled shafting, 66 per cent off list.

Chain, ⅜-in. proof coil, 3.00c.

## The Non-Ferrous Metal Market

During the past month the non-ferrous metal market has been dull, with comparatively little business transacted. Lead has proved strongest, showing larger sales and a good future inquiry. Tin has been unsteady and at times panicky. Spelter is dull and without feature.

**Copper.**—Prices have tended toward weakness and sellers have offered inducements to the trade. At the low level of prices buyers are showing some interest, but are not yet buying heavily. Electrolytic copper is quoted at 13.7 cents, New York. Sales of Lake are reported at 14@14¼ cents.

**Lead.**—This is the most active of the metals and fair sales are reported. Some small sales have been made for export. The market is steady at 3.90 cents, New York, and 3.82½ cents, St. Louis.

**Tin.**—The domestic market has been marked by fluctuations in prices, and the London market has been sensitive.

The latest quotation for June tin is about 31½ cents, New York.

**Spelter.**—Somewhat lower prices have prevailed in this market. Buying is slack and consumers have exhibited little interest. New York spelter is quoted at 5@5.05 cents, and St. Louis 4.85@4.90.

**Other Metals.**—Business in aluminium is quiet and orders are scarce. No. 1 ingots are quoted at 17½@18 cents, New York. Antimony is not specially active and various brands are quoted at 5.75@7.35 cents. A fair business has been done in quicksilver, the New York quotation being $37.50@$38.50 per flask of 75 lb.

San Francisco quotes $37 per flask for domestic orders and $2 less for export.

## Troy Meeting of the American Institute of Chemical Engineers

The sixth semi-annual meeting of the American Institute of Chemical Engineers was held in Troy, N. Y., June 17 to June 20. The meeting was opened at the Pittsburgh Building of the Rensselaer Polytechnic Institute by an address of welcome by Hon. C. F. Burns, Mayor of Troy, followed by an address by President Ricketts of the Rensselaer Polytechnic Institute, in which he referred to the rapid growth of the chemical engineering profession and the development of chemical engineering courses at the Rensselaer Polytechnic Institute and other technical institutes and universities.

The reports of the various committees and officers of the Institute were then presented. The Secretary reported a steady gain in membership which at present is 214. The Treasurer's report showed a substantial balance in the treasury. The Committee on the Standard Chemical Engineering Catalogue reported progress in drafting specifications for the Catalogue.

The following papers were then read: Mr. W. F. Rittman presented a paper on the Applications of Physical Chemistry to Industrial Processes and showed how problems in the manufacture of sulphuric acid, illuminating gas and the fixation of atmospheric nitrogen could be solved by physico-chemical methods. This paper is published in full on page 475.

Prof. J. W. Bain and Mr. A. E. Wigle presented a paper on Filtration, in which they showed the efficiency of filtration and washing of solids under various conditions. It was shown that the amount of liquid remaining in a solid was independent of the size of the particles but varied with the pressure.

Prof. Chas. Boskerville described a very efficient scrubber for vacuum apparatus for laboratories.

Luncheon was then served to the members of the institute by the Rensselaer Polytechnic Institute.

The U. S. Arsenal at Watervliet, N. Y., was visited Wednesday afternoon under the guidance of Colonel Gibson. The shrinking on of the outer jacket of a 14-in. coast-defense gun was witnessed as well as the very interesting operations of riflng the guns and winding guns with rectangular steel wire.

The testing laboratories and buildings of the Rensselaer Polytechnic Institute as well as the gymnasium building and swimming pool were then inspected.

After an informal dinner at the Hotel Rensselaer President Whitaker delivered an address in which he urged the desirability of greater publicity of the experience gained in chemical plants, especially with reference to failures of installations, disastrous accidents and explosions. Great benefit would result to the chemical engineering profession and chemical industries without the losses which would be involved in the publication of the details of successful processes. The address is printed in full on page 437.

Dr. L. J. Matos read a paper on shoddy and carbonized waste showing the methods by which woolen fibre is recovered from rags containing cotton and made available for spinning and weaving. The great economy of this utilization of waste material was emphasized especially in view of the shortage of raw wool. The superiority of much of this recovered wool to many grades of raw wool was shown. The impossibility of distinguishing, in the finished fabric, between raw and recovered wool was also explained. The length of the fibre cannot be used as a test because various grades of the raw wool contain both long and short fibres.

Prof. Wm. P. Mason then showed a number of lantern slides of the Saratoga septic tanks and explained their operation and also discussed a remarkable explosion of one of these tanks, the cause of which has not been clearly demonstrated. Professor Mason suggested the possibility of the combustible gases produced by the bacterial action having been ignited by phosphine produced by the same action.

On Thursday the plant of the General Electric Company at Schenectady was visited. The entire process of manufacture of dynamos and steam turbines was inspected. Special interest was shown in the mercury-vapor engine in course of development, which shows an efficiency 50 per cent higher than the ordinary steam engine. The new Research Laboratories were also inspected, after which lunch was served by the General Electric Co.

The members then proceeded by a special private car of the Schenectady R. R. Co. to Saratoga, where they were shown the springs and the state reservations by the resident physicians who furnished their automobiles for the purpose. After inspection of the sewage disposal plant the return trip to Troy was made in the special car.

In the evening the members took dinner at the Troy Club, after which addresses were made by President M. C. Whitaker, Prof. Wm. P. Mason, Dr. Chas. Ferris of the State Reservation Commission, Prof. Edmond O'Neil of the University of California, Prof. James R. Withrow, Prof. A. M. Green of the Rensselaer Polytechnic Institute and Secretary Olsen. Prof. O'Neil extended an invitation to the Institute to meet in San Francisco in September, 1915.

At the meeting Friday morning at the Hotel Rensselaer, Professor Withrow reported that the Committee on Chemical Engineering Education is cooperating with the Carnegie Foundation in its investigation of the chemical engineering courses given in American colleges and universities and that the Carnegie Foundation has engaged Dr. C. R. Mann to inspect the institutions giving such courses.

The following papers were then read: Mr. John C. Hebden gave the results of a careful study of the chemistry of the bleaching of cotton fibre. He presented analyses giving the composition of the raw cotton as well as its composition after each of the processes of cleaning, bleaching and washing.

Dr. J. C. Olsen and Mr. Wm. H. Ulrich reported the results of experiments showing that ozone oxidizes many substances producing odors, and pointed out many serious errors in the article by Jordan and Carlson on Ozone.

Mr. Maximillian Toch, in a paper on the present patent situation, showed that the new rules for the taking of evidence in patent litigation are not being observed on account of the failure of the United States Government to provide a sufficient number of judges to hear patent cases. Dr. M. H. Iltner also read a paper on patent abuses.

On Friday afternoon the manufacture of collars and shirts was inspected at the factory of Geo. P. Ide & Co. The plant of the West Virginia Pulp and Paper Co. at Mechanicsville was then visited, where both the sulphite and the soda process as well as the electrolytic production of soda and bleach liquor were shown.

Friday evening Mr. L. M. Booth presented a paper, illustrated with lantern slides, on a combination water softener and storage tank. In this installation the calcium and magnesium salts are rapidly precipitated by chemical treatment and mechanical agitation while the clear, softened water is taken off at a suitable height above the sludge. Filtration is thus rendered unnecessary. By making the tank of a sufficient size storage is provided for.

Mr. Richard K. Meade presented a paper giving the developments of the rotary furnace and suggested a number of new applications for this type of furnace. Numerous lantern slides were shown.

The members were entertained at a smoker at the residence of Dr. Wm. P. Mason and were given the opportunity of meeting President Ricketts of the Rensselaer Polytechnic Institute.

On Saturday the plant of the Burden Iron Works was visited where the puddling process for wrought-iron was shown. The attendance at the whole meeting was excellent.

The winter meeting of the Institute will be held in Philadelphia early in December. Dr. John C. Olsen, Polytechnic Institute, Brooklyn, N. Y., is the secretary of the Institute.

## Ninth International Congress of Applied Chemistry

The Executive Committee of the Ninth International Congress of Applied Chemistry, to be held in St. Petersburg, Russia, in 1915, has just issued its first Preliminary Announcement.

The Congress will open on July 26-August 8, and close on August 1-14, the second dates in each case being the dates in the new-style calendar. That is, according to the calendar in use in the United States the Congress will be held[*] from August 8 to 14, 1915.

The Emperor of Russia will be the Patron of the Congress. D. P. Konovaloff, Assistant Minister of Trade and Commerce, will be the Honorary President. Professor P. I. Walden will be the President. Major-General Professor W. N. Ipatiew will be the Honorary Secretary.

All letters are to be addressed to the Honorary Secretary, Ninth International Congress of Applied Chemistry, Winter Palace Place 8, St. Petersburg, Russia (cable address Chimicongress, St. Petersburg).

The membership fee is ten roubles (equivalent to about five dollars), payable in postal money order or check on a St. Petersburgh bank, to the Treasurer of the Congress, V. T. Schaefer, whose address is also Winter Palace Place 8, St. Petersburg.

Applications for membership must contain the applicant's full name, exact address, profession and name of Section or Subsection in which he wishes to take part.

Membership fee must be paid not later than April 1, 1915, if delivery of the printed Transactions is to be guaranteed. The printing of papers will begin in April, 1915, and the size of the edition will depend upon the number of membership fees received on or before April 1-14, 1915.

Ladies accompanying members of the Congress may receive tickets upon the payment of seven roubles. These tickets entitle them to all rights of the Congress with the exception of the right of participating in debates and administrative affairs. Such tickets do not entitle the owner to receive the printed Transactions of the Congress.

"To insure free passage into Russia for all members as well as for ladies accompanying them it is necessary to show at the frontier, in addition to passports with visa, membership cards, signed by the President and Honorary Secretary of the Congress." (In the *Percolator* the same statement is expressed as follows: No obstacles will be placed in the way of the journey of Jewish chemists to the Congress provided that at the frontier, in addition to the vised passport (requisite for every passenger), cards of membership, signed by the President and Honorary Secretary of the IX International Congress shall have been presented.)

---

[*] In the *Percolator* of the Chemists Club of New York of June 18 it is stated that the Congress will be held from August 20 to 26, 1915. This statement is based on the authority of a letter of President Walden of Feb. 20, 1914. We are unable to explain this discrepancy of the dates, but assume that the correct dates are April 8 to 14, as stated in the official Preliminary Announcement, just issued.

The official languages of the Congress shall be Russian, French, English, German and Italian.

The list of the 22 sections and subsections is as follows: 1. Analytical Chemistry. 2. Inorganic Chemistry. 3. Metallurgy and Mining. 3b. Explosives. 3c. Ceramic and Glass. 4. Organic Chemistry. 4a. Colors. 5a. Sugars. 5b. India Rubber and other Plastics. 5c. Fuels and Asphalt. 5d. Fats, Fatty Oils, Soaps and Drying Oils. 6a. Starch, Cellulose and Paper. 6b. Fermentation. 7. Agricultural Chemistry. 8a. Hygiene. 8b. Pharmaceutical Chemistry and Pharmacology. 8c. Chemistry of Foods; Physiological Chemistry. 9. Photochemistry. 10a. Electrochemistry. 10b. Physical Chemistry. 11a. Legislation relating to Chemical Industry. 11b. Political Economy and Conservation of Natural Resources. (The only essential difference from the arrangement of the sections at the Congress in New York City, 1912, is that the former subsections 5e. and 8d. have been abolished and combined with other sections.)

## Paris Meeting of the British Iron and Steel Institute

The autumn meeting of the (British) Iron and Steel Institute will be held in Paris on Thursday, Friday and Saturday, Sept. 17, 18 and 19. On the conclusion of the meeting in Paris a visit will be made to Nancy and to the principal iron mines and metallurgical works of French Lorraine.

The meetings in Paris will be held in the House of the Comité des Forges, Rue de Madrid, Paris.

Mr. G. C. Lloyd, 28 Victoria Street, London, S. W., is the secretary of the Institute.

## A Mine at the Panama-Pacific Exposition in San Francisco, 1915

The U. S. Bureau of Mines has undertaken to construct, in cooperation with the mining industry and the manufacturers of mining machinery, a mine beneath the floor of the Palace of Mines and Metallurgy at the Panama-Pacific Exposition.

Typical metal and coal mining operations will be reproduced by full-size working places in which mining machinery will be installed and operated. The walls of the mine will be covered with either ore or coal typical of the mine illustrated. Among others, the Copper Queen Consolidated of Arizona, Bunker Hill Sullivan Company of Idaho, Homestake Mining Company of South Dakota, Goldfield Consolidated Mines company of Nevada, Jones and Laughlin Company of Michigan, Lehigh Coal & Navigation Company of the anthracite field of Pennsylvania, Pocahontas Fuel Company of West Virginia, Consolidation Coal Company of Kentucky, and Pacific Coast Coal Company of Washington, have each agreed to reproduce one of their working places or stopes and to contribute the sum necessary to the installation and operation. Tentative promises of similar action have been received from the Rock Island Coal Company, Peabody Coal Company, and Pittsburgh Coal Company.

Various mining machinery and appliances have been promised, including a mine cage and cars by the Joshua Hendy Company; a cage, hoist and motor by the Denver Engineering Works; locomotives by the Westinghouse Electric & Manufacturing Company; pumps by Byron Jackson; air compressor, drills, drill sharpener and winze hoist by the Compressed Air Machinery Company; drills and coal cutters by the Ingersoll Rand Company and the Sullivan Machinery Company; lamps by the Justrite Manufacturing Company and the Koehler Manufacturing Company; enamel signs by Stonehouse Enamel Sign Company.

The entrance to the mine will be through the Bureau of Mines space, and visitors will be attracted to it by being given portable mine lamps, and by being lowered in a very slowly moving cage while a panoramic effect of the strata lining a mine shaft will pass by them so rapidly as to produce the illusion of descending to a considerable depth. In case of crowds, these may enter by a slope. Exit will be by a slope into the radium booths of the Bureau of Mines where radium emanations will be shown.

There will be a motion-picture room which visitors will pass in going from mine to mine. In it will be shown such great open workings as are not illustrated by the underground mines, such as those of the Utah Copper Company and those of the Nevada Consolidated Company at Ely, the iron diggings at Hibbing, Minn., hydraulic gold mining, and the quarrying of building stone.

Twice each day there will be an imaginary explosion or fire in some portion of the mine announced by telephone to the superintendent's office in the Bureau of Mines space on the surface, and rescue men wearing breathing apparatus will enter the mine and bring out supposed victims who will be given first aid treatment in the surface emergency hospital.

In the Bureau of Mines space on the floor of the main building, there will be, in addition to the radium booths, exhibits of carnotite, pitchblende and other radium ores, their alloys and concentrates, an emergency mine hospital and smoke room for rescue training, exhibits of fuel efficiency, smoke abatement, explosives, mine welfare work, etc.

The prime purpose of the mines will be that of educating the investing public, stockholders, members of legislatures and the uninformed antagonists of the industry relative to the importance of the mining industry, its extent, variety and the cost of operation.

---

Electric Hoists of one-ton or two-ton capacity are the subject of Bulletin 301A of the Pawling & Harnischfeger Co., Milwaukee, Wis. The system here described should be particularly attractive for such industrial plants in which hand labor is still employed for lifting loads and carrying them over short distances. In such plants an electric hoist with 200 or 300 feet of runway will in most cases pay for itself inside of a few months as it will replace from three to ten men, depending on conditions, and can be easily and quickly installed. The design in question is an overhead monorail hoist, traveling on the lower flanges of an I-beam. The illustrations in the bulletin show the application of this hoist for lifting heavy paper rolls in a printing shop, for handling pipes, rods and plates in steel works, for carrying boxes in a warehouse, etc. When the hoist is equipped with electromagnets for handling iron bars, plates, etc., the operator handles the load alone without other help. Another illustration shows the very complete monorail system with turntables, crossovers, switches, etc., installed at the International Harvester Co.'s plant at Milwaukee, Wis.

Calendar—"Again we say what is so rare as a day in June for a new calendar?" The Wagner Electric Company of St. Louis, Mo., has issued a very attractive calendar, covering the period from June, 1914, to May, 1915. The picture on the calendar is that of a little boy in quiet but evident admiration of a little motor.

# Some Professional Obligations*

BY M. C. WHITAKER

Chemical engineering as an organized profession is comparatively new, although many men have been engaged in this class of work since the beginning of large-scale manufacture. Since the organization of this Institute, various definitions have been given to outline the scope of our professional activities, many schemes have been suggested to improve the training of our apprentices, some advances have been made towards standardization in our engineering practice, a code defining the ethical standards of our profession has been formulated and adopted, and we have shown our aims, with some results, in constructive patent reform.

Work of such a character is of the greatest importance, and is far in advance of that heretofore undertaken by any other organization in our field. It can never be regarded as completed, and the best thought and effort of well constituted committees will continue to be given to advancement along these lines, with great resultant benefit to the profession.

There comes a time, however, in the life history of every organization or enterprise when the greatest advancement and improvement may be made by a process of introspection. It would seem to the speaker that chemical engineers might now, with great profit to themselves and benefit to the profession, submit to a process of self-analysis. Obviously it would be out of time and place to attempt now a profound or philosophical analysis of our internal personal relations and aims, but it is hoped that by reference to a few of the more fundamental points we may thereby catalyze some productive reactions.

Chemical engineering must, sooner or later, come to be recognized as the leader among the engineering professions. Its interests are larger and more varied, and its scope is greater and more intimately related to social and industrial progress than that of any one or all of the other branches of applied science. Manufacturing output in the United States, which in money value is already almost equal to the largest single productive interest, will be dependent in some, if not in all, of its steps upon the chemical engineer. The burden of the development of the industrial processes and the operation of the plants will fall upon him, and naturally the rewards of success and the odium of the failures will be his. The realization of the opportunities of such a profession, so full of brilliant promise and great possibilities, will depend in a large measure upon the breadth of view adopted in the acceptance of our responsibilities.

A voluble assertion of our importance will not give us the power to master our calling. Professional prestige, in the engineering field at least, is built upon achievement. Achievement worthy of the dignity of a profession cannot be built upon independent work, the spectacular results of a few individuals or the hit-and-miss strokes of fortune. It must be based upon a consistent development of and by a body of able progressive men, and be based upon years of unselfish constructive co-operation, in which each member contributes his share, and in turn, draws freely from the common store.

The legal, the medical and the clerical professions have devised for themselves some form of legal protection. The engineering professions, on the other hand, are subject to no form of external control, and may become self-developing or self-effacing according to the wisdom of the policies adopted in their direction and development, and the positiveness and value of their achievements. Merit, after all, is the only measure of success in engineering, and all failures, and even doubtful results, are promptly charged off against the profession.

The civil engineer may design and build a bridge. During construction his work is open and in full view of the public and his colleagues. There is not a single feature of his purpose, his design or his materials of construction which is not common knowledge to anyone who takes the trouble to look at his work, or read any of the numerous articles published during its progress. Even the lay public may be interested and pay their tribute to the man behind the work. The finished bridge stands in public as a monument to the power and ability of the builder and the profession he represents.

The mechanical engineer may design and build a wonderful machine. There is no secret about any of the features. His colleagues, the public, or anyone may study and criticize his work, accept and profit by his suggestions and ingenious features, or may avoid his mistakes. The mechanical engineer has profited by the successes and failures of his predecessors in the art, and his successors, in their turn, will build better as a result of his work.

So it is with the mining and the electrical engineer. Each works with a full knowledge of what has gone before; each contributes his share to the advancement of his art, and the standing of the professions is enhanced because of his contributions.

The chemical engineer, on the other hand, works in unappreciated silence behind factory walls. He is not building a monument which invites public approval, though he may be making a product of equal value and more wonderful if it were understood. The details of his work are carefully guarded, and he is even denied the stimulus of public interest in his achievements. His designs, materials and methods often lack the helpful suggestions of his fellow engineers. He may repeat at great expense the mistakes previously made by his neighbor, or may fail to avail himself of well worked out methods which are unknown to him on account of lack of proper exchange of professional knowledge.

If he is secretive it comes as a result of environment and conditions. This secretiveness often becomes a habit and is assumed to be a necessity. At times this habit is extended either unconsciously or accidentally to ludicrous limits.

For example, note how difficult it is to find the professional or business connections of a chemist or chemical engineer. Surely there is nothing about this which should be concealed. On the contrary, good would result both to him and his employer by having his connections and field of activity well known. The directories of all other engineering societies contain valuable information about the professional activities of their membership, while our directories in many cases carefully disguise even the business addresses of our members.

The chemical engineer's efficiency in the production of successful results is reduced to a minimum, because of a lack of liberal professional co-operation, while civil, mechanical, electrical and other engineers are steadily improving their professional efficiency by a systematic exchange of principles and practices, and a selective action to carry forward the good methods and reject the bad ones. We of the chemical engineering profession are harboring conditions which retard or frequently even prevent professional progress.

When the work of the chemical engineer is not open to public view, his productive efforts not understood, and therefore not appreciated, his achievements cautiously guarded, his business connections withheld from the directories of his societies and absolutely no record of his professional activities is made available, is it any wonder the lay public usually think of him as a druggist?

---

*Presidential address delivered before the American Institute of Chemical Engineers on June 17, 1914.

If one traces the life history of the development of the chemical engineer, it will be found that we have some bad traditions to overcome. Our alchemist forefathers cultivated secretiveness, mystery, and even deception. These dark-art traditions are openly professed to-day in some of our factories, while in others they remain in latent evidence.

With these adverse conditions and traditions in existence it would seem that the chemical engineers are confronted with an important problem which intimately concerns the progress and development of the profession. Inefficiency and loss of prestige are bound to result from unsupported individual effort. Co-operation is essential to substantial engineering development. This co-operation comes about naturally in other engineering professions, and it will have to come, if not naturally then by force of necessity, in ours.

Every failure in design, every fatal accident, every industrial disease, every fire or explosion in a chemical works, every commercial insuccess is an indictment against the chemical engineering profession. Cause and effect in bridge failures, dam failures, boiler explosions, railroad and steamship wrecks, are freely discussed in conventions and journals for the benefit of the interested profession. These open and frank discussions disarm public criticism on the one hand, and on the other place before all members of the profession most impressive and profitable lessons in what not to do.

The chemical engineer in such cases, apparently guided by his ancient traditions, or his environment controlled habits, as no other motive seems discernible, often secretes the facts not only from the public hut also from his professional associates. Such secretiveness always arouses public suspicion. The interests of humanity may be sacrificed, and the profession, without the knowledge of what has happened, may go blundering into the same disaster again and again. These costly disasters are not even recorded as experience outside of the factory walls in which they occur.

Have the chemical engineers discussed or even heard of the causes leading to the failure of the coke plant at Bethlehem; the cause and effect of the explosion in the artificial leather factory at Detroit; the lessons to be drawn from the recent fire in the Mallinckrodt works in St. Louis; the cause and effect of the failure of a large gas holder at Philadelphia; the cause or remedy of the large number of industrial diseases in some of our plants; the complete failure of this or that piece of equipment or method of installation?

Do the affected or afflicted chemical engineers seek the assistance of their associates and professional colleagues in determining the cause, and suggesting the remedy for such disasters? If the cause and the remedy are determined, are the facts made public?

Think of the benefit which would come to our profession and to humanity and industry in general from frank authoritative discussion of these and many other problems which come within the experience of every chemical engineer. The discussion of the defective design, or material, or installation of chemical engineering appliances is a thing which would be of inestimable benefit, not only to other engineers, but also ultimately to the producers of the appliances. Negative results can be of no possible value to those industries which have developed them, but if they were published or discussed they would become of the greatest importance to future engineering progress. Why should they be jealously guarded and secreted and the progress of this profession thereby blocked?

The question as to what knowledge the manufacturer should disclose for public use and what should be kept within the factory walls is one which may be settled by the rule of reason, but never settled by yielding to the inclinations of our natural environment and our ancestral traditions. When it becomes clear that these conditions are blockading engineering progress and our own professional development, it will not be simply a duty, but an obligation, for every chemical engineer to apply this rule of reason.

Property value might safely be accepted as the basis for determining what should and what should not be disclosed. Manufacturers and chemical engineers would not be expected to give out unprotected information of direct property value any more than civil engineers would be expected to publish their working drawings before the contracts were awarded, or the mechanical engineer be expected to give away the appliances in which he had invested his time and his money. Such a policy would result in commercial anarchy and tend to destroy industrial stability and with it the dependent professions.

Fortunately it is very often the knowledge having the least property value which, when collected and classified, possesses the greatest professional value. Negative results can usually be disclosed without loss and they form the most substantial basis for engineering development.

On the other hand, the publication of the failure of a design, a material or a process would invite constructive thought from others which might turn a failure into a success, or suggest to our young investigators researches which would definitely establish or disprove the scientific validity of the principles involved.

The interests of humanity demand that industrial diseases, industrial accidents and improvements in working conditions be openly and frankly discussed in order that the combined effort of all minds be brought to bear on the needed solutions. Proper publicity in all bad or doubtful cases would do much to soften the hearts of the financial control, and at the same time independently enlist the services of the physiological chemists, the medical researchers, the mill designers and many minds in our own profession which is most seriously indicated.

We have all heard the statement by members of this profession that there are no adequate textbooks or handbooks in chemical engineering of the same standard of excellence as those existing in mechanical engineering, for example. Such books, in any engineering field, are the results of compilations and classifications of approved matter from current technical journals and society proceedings, and it is inevitable that they will be large or small, dense or rare, profound or superficial, in direct proportion to the current available material.

If we secrete our information, or fail to publish our researches, hoard our knowledge and avoid the full and frank discussion of our industrial problems, we are bound to reap the negative rewards. Our books will not represent the sum of a profession's knowledge, but instead the comparatively small, laboriously attained work of one or a very few individuals.

This institute, representing as it does the leading organization devoted exclusively to developing the technical interests of the chemical engineers, and enhancing the prestige and value of that profession, should be the first to consider all obstacles to the accomplishment of its purpose. Our profession is built upon the applications of a science of the most infinite and varied detail. The mastery of modern chemistry requires a highly developed mind and one which should be fully qualified to attack and solve with ease the problems of policy in the development of the profession.

Our organization is new and the problems are large and numerous. Most careful consideration must be given to the direction of our energies into those channels in which we shall find the most productive returns. We have no time to waste on philosophical quibbling or fussy arguments. If self-analysis shows that the indictment of narrowness is valid and that the best interests of our profession will be served, as I think they will, by a more active interest in public questions, such as the so-called conservation movement, public service control, corporate regulation, financing of industrial enterprises, etc., then we should study and discuss these problems in our meetings and proceedings.

If chemical engineering education is twenty or thirty years behind the methods and efficiency of mechanical and electrical engineering training, as I think it is, and its improvement is being blocked by the dogmatic teaching that chemical manufacture is nothing more than enlarged laboratory practice, it then becomes evident that even more strenuous efforts will be required from this institute and its hard working committees to produce the desired results.

If, as I firmly believe, our professional progress is being seriously blocked by an unjustified and unjustifiable veil of secrecy or mystery drawn around our experiences, our needs, our achievements and our professional activities, the removal of this obstacle to our advancement becomes an obligation upon each constituent member of the chemical engineering profession, and particularly upon the Institute of Chemical Engineers.

Chemical Engineering Laboratories,
Columbia University, New York.

---

## Physical Versus Chemical Actions in Furnaces

BY CARL HERING

In many furnace processes, aside from simple melting, there are often both chemical and physical changes which either consume or set free energy, hence must be considered in processes in which the cost of the electric energy is of importance.

In books the energy involved in a chemical change or reaction, and generally though erroneously called "heat" of combination, is given in a lump sum regardless of how much of it is for the purely chemical part of the total and how much for the physical parts which may be involved in the change. By a chemical change is here meant a rearrangement of the atoms which results in a different chemical compound or product; by a physical one is meant a change of state of any parts of the material, say from solid to liquid or gas, or to a solution in a solvent, or a change of temperature, etc., hence it includes all changes other than the chemical ones.

For instance, when $Fe_2O$ is combined with C in a pig-iron blast furnace,, the chemical changes are the reduction of the iron oxide and the oxidation of the carbon; while the physical changes are the liquefaction of the solid iron and the vaporization of the solid O and the solid C into a gas, hence involving an enormous expansion against atmospheric pressure (about 7000 to 8000 fold) and the latent heats of both fusion and vaporization of C and O.

In books the enegies involved in these various changes are jumbled together into one amount. The object of the present note is to call attention to the desirability of separating them into their component parts, at least for electric furnace processes in which the energy consumption is important; by thus separating the parts of the whole into the chemical and the physical energies, it may sometimes be found to be cheaper to do the physical part by other means than by electric heat or it might be possible to prevent an energy consuming physical change from taking place, or perhaps even bring about an energy producing one; the purely chemical changes might perhaps also be facilitated in such ways.

When we know how much of the energy involved in a furnace process is physical and how much is purely chemical, it becomes possible to estimate whether that process might perhaps be cheapened by saving some of the energy involved in the physical part or by producing it more cheaply. The chemical changes, being the ones usually wanted, cannot of course be avoided, but even the energy involved in these purely chemical reactions might be modified by different physical conditions; for instance, near the temperature of the dissociation point of a chemical product the energy involved in making or breaking chemical bonds is much less, and this dissociation point might perhaps be raised or lowered as desired, by purely physical means other than heat, as for instance by pressure.

Some electric furnaces can be operated commercially at a positive or a negative pressure, and if this is an advantage, it might be possible to produce such pressures cheaply, thereby saving some of the electric heat.

If, for instance, a final product ordinarily leaves the furnace as a gas, but has entered it as a solid, as for instance in the production of zinc, arsenic, phosphorus, sulphur, etc., both the latent heats of fusion and vaporization must be supplied as electric heat, as must also the energy involved in the enormous expansion from a solid to a gas, and perhaps also the heating of this gas. But if by means of a positive pressure such a product could be kept liquefied in the furnace, and removed in that form, the energy required for these physical changes would not have to be supplied electrically to the furnace.

A negative pressure, on the other hand, might in other cases so reduce the vaporization temperature of a gas which is to be eliminated that less furnace heat would be required to accomplish its separation. Or in general, when a gas like CO or $CO_2$ is generated from solids and must be removed, it would consume less furnace heat to have it expand into a vacuum than against atmospheric pressure.

Numerous other cases might be cited to show the energy effect of the purely physical part of a process. Water might electrolyze easier in vacuum than if the gases must expand many hundreds of times against a pressure of 15 lb. per square inch, which consumes energy. Some of the impurities in molten steel might be more cheaply removed by a negative pressure (suction) than by chemical reactions, or than by calories alone, as in producing greater fluidity. If the oxygen in iron oxide is removed as a solid, by a solid, and the product is also a solid (or liquid), the energy for its expansion into a gas (physical) is saved; that is, there is no lowering of temperature due to this expansion; this is one of the causes of the high temperatures in the thermit reaction which is of this kind. If a gas, like hydrogen, combined with solid oxygen (in an oxide) the product being liquid water, the energy of the great contraction of the gaseous hydrogen to a liquid must be set free, hence is a gain and might perhaps be made to be available.

It is therefore thought by the writer that a clearer distinction between the physical and the chemical parts of a desired process may lead to a better understanding of what actually takes place; that is, it may give us a better mental picture, and this in turn might aid in improving or cheapening a process. Hence the writer claims that the energies of the chemical changes of compounds, or "heats" of combination as they are loosely called in books, should in future be stated in their component parts, with a clear distinction between the chemical and the physical, the latter being again subdivided into its constituent parts; the diminution of the chemical energy with a rise of temperature should also be stated. With this detailed data it would then become possible to estimate whether it might cost less to do the physical part in some other way than by expensive electric heat, or at least to facilitate it.

When the total "heats" of combination are thus resolved into their components, the speculative thought suggests itself that perhaps some of the apparently endothermic (energy absorbing) processes which take place spontaneously are in fact exothermic as far as the purely chemical part of the process is concerned, their endothermic character being perhaps due to the physical parts of the process.

When steam is heated to increasingly high temperatures, a point will be reached at which the chemical affinity of the hydrogen and oxygen becomes zero; this is known as the dissociation point; the molecules of these elements mixed together then have little more concern for each other than black and white marbles have when mixed in a bag. Their energy of chemical combination must therefore have been supplied during this heating process, yet all the heat that was added ostensibly merely increased the temperature, hence is, according to the books, classed under specific heat. This high temperature dissociation applies not only to steam but to most other chemical combinations.

It would be hard to believe that in such a case the energy of combination which was evidently supplied while the temperature was being raised, was taken up suddenly at any one temperature, like the latent heats of fusion and volatilization are, unless there is experimental evidence to this effect. It is more than likely that the real facts are, that as the temperature of a compound is gradually raised the chemical bond is weakened more and more until it becomes zero at the dissociation point; hence at that point all the energy of combination has been supplied to the material.

If that is the case, then what we call specific heat is not entirely such for compounds, but consists of two parts, a real specific heat and a part which goes to reducing the energy of the chemical bond, a physical and a chemical part; the chemical affinity grows weaker as the physical activity increases.

The rates at which these affinities thus decrease with a rise of temperature is apparently different for different chemical combinations, hence the curves representing them may and apparently do intersect in many cases.

If this is correct, then it does not seem irrational to suppose that in raising the temperature of the iron oxide, a portion of the energy of combination of the iron and its oxygen has really been supplied under the guise of specific heat (physical), and the bond has been weakened to such an extent that at the temperature of the reaction the affinity of the carbon for the oxygen exceeds it, and in that case the chemical reaction itself would continue spontaneously, as we know it does.

As explained above, there are moreover some purely physical changes in this reaction which must also be considered in the equations representing the energy transfers, or else they will mask the real actions. The carbon and the oxygen are changed from a solid to an expanded gas. The energy for these physical changes must be supplied from some source. If not added to the system the materials may be robbed of it, which means a lowering of the temperature; hence to keep up the temperature necessary for this chemical reaction heat must be supplied as fast as the oxygen and carbon are volatilized and the iron melted.

This necessary supply of heat has probably by some been erroneously supposed to be part of the energy of the purely chemical part of the reaction. It will readily be seen, however, that this part is purely physical and not chemical at all, though in using terms loosely the chemical and physical parts may have again been jumbled together in some books, just as the purely physical specific heats seem to have included parts of the chemical energy, as mentioned above. Carelessness in not distinguishing between the physical and the chemical parts of a process may lead to much confusion and erroneous deductions and conclusions.

*Philadelphia*, June, 1914.

---

**Sulphuric acid** produced at zinc and copper smelters is a factor of increasing importance in the acid industry of this country. According to figures compiled by the U. S. Geological Survey, the 1913 production from this source amounted to 790,296 short tons of 50 deg. acid, valued at $4,346,272. Copper smelters produced slightly more than zinc smelters.

**Statistics on the world's zinc industry** and trade have been compiled by the Department of Commerce from information furnished by the various U. S. consuls. The following tabulation gives the output of spelter for 1913:

| Countries | 1913 Short tons. |
|---|---|
| Australia | 4,105 |
| Australia and Italy | 23,856 |
| Belgium | 217,941 |
| France and Spain | 78,293 |
| Germany | 311,914 |
| Great Britain | 65,201 |
| Netherlands | 26,813 |
| Norway | 19,040 |
| Poland | 9,520 |
| United States | 346,676 |
| Total | 1,103,359 |

**Gas Producers.**—The Pittsburgh Plate Glass Company have just placed an order with the Chapman Engineering Company, Mt. Vernon, O., for five 10-foot inside diameter Chapman rotary gas producers. These are to be installed in their No. 11 Works, Mt. Vernon, Ohio, and supply gas for their two furnaces previously using natural gas. This is the second important installation of Chapman producers made by the Pittsburgh Plate Glass Company. The American Bottle Company are installing in their Newark, Ohio, plant one 10-foot Chapman producer to replace natural gas. This also is a second Chapman producer installation for this company. The American Clay Company, Terre Haute, Ind., have recently placed in operation one 10-foot producer, which replaces three hand-poked machines. The gas is used for burning hollow building tile in continuous kilns. The Chapman producer has reduced the coal consumption, decreased the time necessary to burn, and increased the percentage of good ware.

**Reserves of zinc concentrates** in the Joplin district, according to the authority of Mr. L. L. Wittich, are not acting as a bear on prices. They amount to 12,000 or 14,000 tons, the largest accumulation being 4000 tons at the Mont B mine. These concentrates cannot be bought at prevailing prices.

**The value of Utah's mine output** of gold, silver, copper, lead and zinc in 1913 was $44,858,210, according to the U. S. Geological Survey. This is an increase of nearly $2,000,000 over 1912. The silver production showed a slight decrease. There was a large increase in copper, the Bingham district producing 145,000,000 pounds. The total quantity of all ore sold or treated in the state during the year was 10,202,566 tons. The average recoverable value was $4.39 per ton. Gold production was valued at $3,565,229; silver amounted to 13,084,835 ounces; copper, 161,445,962 pounds; lead, 166,126,790 pounds, and zinc, 18,857,827 pounds.

# Electrolytic Refining of the Precious Metals

## The Plant of the Geneva Gold Refinery

BY H. LACROIX*

The electrolytic apparatus used by the Geneva Gold Refinery (Usine Genevoise de Degrossissage d'Or) for refining the precious metals has been described in detail in a previous article (see March, 1909, page 109-111 of this journal). The principle on which it works is well known and we will only give a description of the installation as it has been in operation during the last five years, together with the results which can be achieved.

At the Geneva refinery there are three different processes of electrolytic refining in use, namely, those of Dietzel, Moebius, and Wohlwill. The use of each depends on whether the alloy is rich in copper, in silver or in gold. These three different processes have led to the construction of three different types of apparatus, the design of which is based on the same principle but which vary in their dimensions in the materials of which they are made and in their shapes.

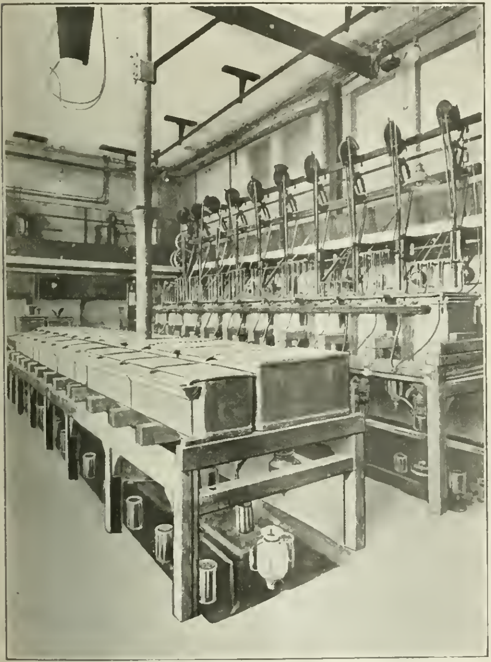


FIG. 1—INSTALLATION AT GENEVA REFINERY

Before describing these installations it will be of interest to say that few refineries labor under such unfavorable conditions as the Geneva refinery as regards the quality and the tenor of the alloys to be refined. With the exception of the refining of gold ingots from the mines, all the alloys refined in the gold refinery are derived from commercial bars, which are the residues of all kinds of work shops, poor in precious metal and containing large amounts of base metals, lead, copper, zinc, tin, nickel, aluminium, etc. In the Dietzel refinery the average content of gold plus silver scarcely exceeds 5 to 600 per thousand, and in the Moebius plant the average content of gold plus silver reaches 900 to 910 per thousand at the most. In spite of this all these materials are treated electrolytically without any preliminary chemical solution.

### Refining Silver-Copper Alloys

This installation (Fig. 1) consists of ten stoneware electrolytic tanks (Fig. 2) with four diaphragms each. The contents of the alloys treated here vary from 0 to 250 per thousand for gold and from 100 to 700 per thousand for silver.

The Dietzel process in use is well known. The desilverized solution coming from the desilverizing tanks is passed into an upper reservoir, where it is acidified, and is then distributed into the ten electrolytic tanks. The liquor is circulated in these tanks, passing from the cathodes, which are of copper, to the anodes (Fig. 3); these latter are suspended inside of diaphragms in which the silver collects. The liquor overflowing from the ten tanks is led through a common drain into a filter press and from there into a collecting tank. From there, by suitable tubing, it is distributed in the desilverizing tanks which are supplied with copper plates. These tanks are arranged in pairs one above the other; each pair is fed separately. After desilverizing, the liquor is collected in a common tank below, from whence an electric centrifugal pump raises it into the upper tank.

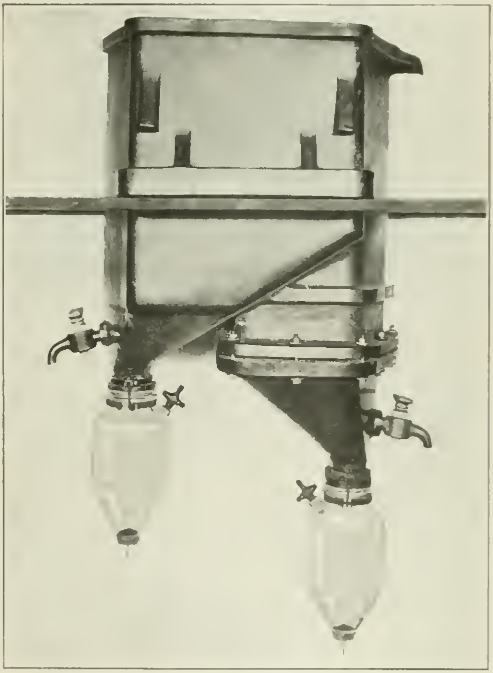


FIG. 2—ELECTROLYTIC TANKS

As electrolysis proceeds, the gold and insoluble anode residues precipitate and collect in the flask at the right-hand side, while part of the copper deposit which on account of the great density of the current does not adhere to the cathodes drops and collects in the flask at the left. These two precipitates are withdrawn by means of the arrangement described in the above-mentioned article; the arrangement consists of special flasks with globe valves which allow the removal of a stopper in the lower part. This operation is performed once a day with the flask containing the anodic residues; it requires only a few minutes to do this and no interruption of the circulation in the bath or the passage of the electric current is required.

---

*Translated by Alex F. Fuerst

The anodic gold can thus be withdrawn as fast as it falls and it is not necessary to wait for the complete consumption of the anode.

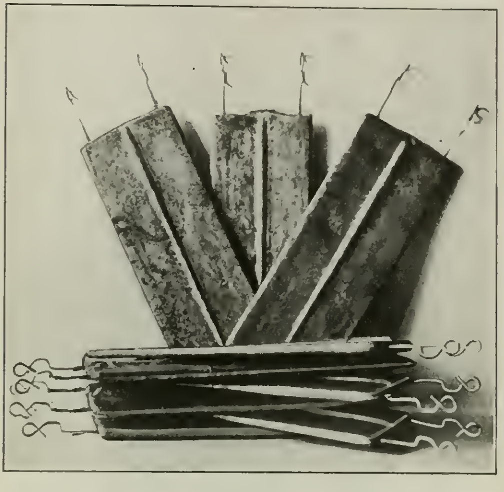


FIG. 3—ANODES

The silver which falls in the desilvering tanks, having a conical bottom, is withdrawn in the same fashion, twice in twenty-four hours. The silver is washed in a revolving drum and the wash water returns automatically to the tanks that fill the flasks after withdrawal. The current density employed is about two amperes per square decimeter.

### Refining the Silver

The type of apparatus used for this process differs from the previously described apparatus only in having the left glass flask (of the cathode side) replaced by a stoneware recipient of large capacity. The same is large enough to hold a twelve-hour production of silver and is connected with the tank by a large joint. The anodes are suspended inside of diaphragms and the withdrawal of the anodic residues is accomplished as described above.

The cathodes are of silver or aluminium, outside of diaphragms. The silver deposit is detached by scrapers which automatically scrape from above downwards; the silver falls into the stoneware recipient below, from where it is removed twice a day.

The principle on which this removal is accomplished is the same as above, though modified on account of the withdrawal of a large quantity in one operation. The flask with globe valve is replaced by a funnel provided with a globe valve. The funnel possesses an arrangement by means of which the stopper of the stoneware recipient may be drawn and its contents emptied through the funnel into a stoneware jar below, which is mounted on wheels. By means of this apparatus large quantities of material are withdrawn in a short time and its adoption in other branches of chemical industry should prove advantageous.

As in the previous plant, the bath also circulates from the cathodes to the anodes and is raised outside of the electrolytic tanks automatically from a lower collecting tank to a higher distributing tank.

### Refining the Gold

The electrolytic tank of the Geneva refinery has given excellent results in the two processes described above. But in its application to the Wohlwill process of refining gold it has been most successful, rendering this process efficient, rapid, producing a gold of great fineness and reducing manual labor.

The apparatus in use are in principle the same as described above for silver and copper; they are only smaller, have only two diaphragms, and are made of porcelain and the lower flasks are of glass. The anodes are suspended in pairs in each diaphragm from the busbars by means of silver hooks. The cathodes are clamped on top in groups of three on three busbars outside the diaphragms.

The chloride of gold bath (*loc. cit.*) circulates from the cathodes to the anodes, rising on the former and descending on the latter, after having passed through openings left in the upper part of the diaphragms.

The circulation takes place in the same direction as would naturally result from the change in concentration at cathodes and anodes of a bath that is left undisturbed. For high current densities such a natural circulation is much too slow, because a rapid impoverishment of the bath near the cathodes would take place and a bad deposit would result. In practice an internal circulation is established by means of a screw propeller.

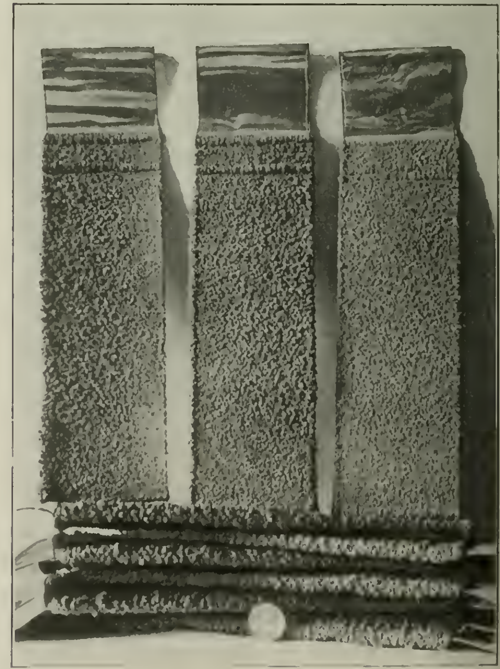


FIG. 4—CATHODES

This manner of circulating the bath in tanks without diaphragms has the drawback of stirring up the precipitate of chloride of silver so that small particles of it are carried mechanically to the cathode gold and lower its fineness. In some refineries such cathodes are once more refined by being used as anodes in other tanks.

By the use of diaphragms, however, in which the level of the bath is a few millimeters lower than on the outside, the chance of carrying chloride of silver towards the cathodes is absolutely excluded, no matter how rapid the circulation may be. The rapidity of circulation can, therefore, be greatly increased, especially with impure baths.

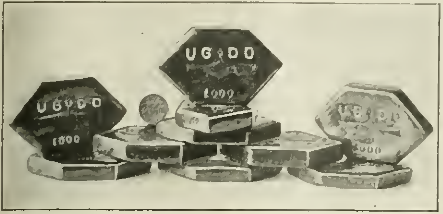


FIG. 5—MELTED CATHODE GOLD

As seen in Fig. 4 the deposit on the cathodes is absolutely uniform all over. In descending along the anodes the circulating bath becomes richer in gold, the particles of chloride of silver are detached and are carried along to the lower parts of the apparatus and collect in the lower flask by gravity. In the apparatus of the Geneva refinery the rate of circulation is about 5 to 10 liters per minute per square meter of cathode for an average bath. This represents a complete renewal of the cathodic solution within five to ten minutes.

The melted cathode gold (Fig. 5) always assays 1000 fine.

The gold bath on leaving the electrolytic tank runs into a lower tank from where it is automatically pumped by electric power into a higher distributing tank. From this latter it re-enters the apparatus after having passed a special steam-heating device where it acquires the necessary temperature. During this circulation outside the electrolytic tank the necessary additions of chloride of gold and of acid are made and a tank holding the wash waters, automatically keeps up the normal volume of solution and compensates for the loss by evaporation. The chloride of silver is removed once a day from the lower flask in the manner described above.

The current density can be pushed to 12 to 14 amp per square decimeter of anode, depending on the copper contents of the solution. The normal density is 9 amp per square decimeter at the cathodes and 11 amp per square decimeter at the anodes. This permits the refining of anodes of 8½ mm thickness in about thirty hours. The fineness in gold of the anodes is about 850 to 950.

For lower fineness a special arrangement is required for the removal of the chloride of silver: either pulsation current may be used, Wohlwill's patent,[1] or scraping of the anodes. The automatic scraper of the Geneva refinery possesses horizontal scrapers moving vertically in front of the anodes and pressing against them on descending, but receding on the rise. The anodes are thus scraped no matter what their thickness or their condition may be.

The diaphragms are sealed inside the electrolytic tanks with the exception of the openings in their upper parts, which establish communication between the anode and cathode baths. Good diaphragms resist well the action of the bath, in spite of its strong acidity and its temperature. Those actually in use have been working now for four years without any repairing.

Before concluding we wish to compare the cost, for example, with those given for the electrolytic operation at the San Francisco Mint, as described[2] in detail in the *Engineering and Mining Journal* of Nov. 4, 1911.

This latter installation consists of two series of fourteen rectangular tanks; the cathodes formed in the first series assay, for the reasons given above, 998.7 and are put in again as anodes in the second series, assaying finally 999.7 gold. According to the dimensions given the anodes weigh about 3.35 kg or, for a series of fourteen tanks with eight anodes each, 380 kg, which are worth about $240,000, or $480,000 for both series. The interest on this locked-up capital amounts to $19,200 at 4 per cent per annum.

With the electrolytic tanks of the Geneva Refinery, which yield directly gold 1000 fine and which work with an anodic current density of about 10 amp per square decimeter (as compared with 7.5 amp at San Francisco) the locked-up capital would not be more than $480,000 $\times \frac{1}{2} \times 7.5/10$ = $180,000, representing an interest of $7,200 per year. The saving would therefore be $12,000 per year without taking into account the interest for the baths and the manual labor.

Geneva, Switzerland.

---

[1] See MET. & CHEM. ENG'ING, vol. VIII, p. 82.

[2] See also *Electrochem. & Met. Ind.*, vol. VI, pp. 355 and 408 (1908).

---

## Superheated Steam on Railway Locomotives

The Midland Railway Company has been making an extensive series of tests with various types of locomotives with the object of ascertaining the efficiency of super-heated steam as compared with saturated steam under the same conditions; and in a paper recently read before the Institution of Civil Engineers Mr. Henry Fowler gave some very interesting statistics which seem to establish the great superiority of the superheated steam; but the author also stated that the Midland Railway Co. had not yet had sufficient experience to be able to give definite figures for costs of maintenance, although everything indicated that they would not be greater than those for engines using saturated steam. Yet he was able to say positively that the wear on the boilers of superheater engines was considerably less than was usually found in locomotives using saturated steam doing similar work; and consequently they could be run for longer periods without being "shopped" and were also a proportionately shorter time out of service. The cost of maintenance was undoubtedly increased by the extra equipment on the superheater locomotive, but he estimated that the saving on boiler repairs would more than compensate for that increase.

The saving effected by superheating, in a series of tests with two similar 4—4—0 engines, each of which had six double runs between London and Leeds, was 23 per cent of coal and 22 per cent of water per ton-mile; and after the superheater engine had run 62,000 miles without "shopping" the consumption of coal and water increased by only 1.5 and 2.8 per cent respectively. Tests with the same superheater-fitted engine against a three-cylinder compound engine showed a saving of 15 per cent of coal and 17.5 per cent of water in favor of the former. Other tests on runs between London and Derby with two engines rebuilt alike in every respect, save that one was equipped with a superheater while the other used saturated steam, gave a reduction of 30 per cent of coal and 34 per cent of water for the superheater. Subsequently in one of the three cylinder compound engines the steam going to the high-pressure cylinder was superheated and a test against an exactly similar engine using saturated steam showed reductions of 25.9 per cent in coal consumption and 22.3 per cent in water in favor of the superheater. No disadvantages were found to result from the high temperature in the hp. cylinder after three months' running.

# The Electric Iron Smelting at Hardanger in Norway

BY JOH. HÄRDÉN

The third and last part of Mr. Oedquist's paper on the above subject has now been published[1] and the following is a review of its content.

The paper concludes: The results at Hardanger have shown that coke *can* be used as a reducing agent in furnaces of this type. But this does not of course permit the conclusion that this particular design of furnace is fully suitable for working with coke as a reducer.

The advantage of using coke instead of charcoal in ordinary blast-furnace practice is partly the lower price of the coke, and also the fact that furnaces for coke firing may be built for very large capacities.

In electric furnaces of the type used at Hardanger, however, the coke does not play such a great rôle as regards the quantity of production; in these furnaces the capacity is depending upon the number and the size of electrodes used, which in turn determine the amount of power applicable to the furnace. Consequently the advantage of larger units when coke is used can be disregarded, and only the lower cost of the coke need to be considered.

Against this stands the fact, as well known, that the use of coke has other disadvantages; for instance, that the coke carries various impurities, especially sulphur. These disadvantages are even more pronounced in the case of electric smelting, where the aim has been, at least up to the present, a quality considerably higher than that of an ordinary coke-blast furnace.

Should, therefore, any gain be obtained by using coke instead of charcoal, it must be possible to produce a material cheaper than charcoal-pig, and even so much cheaper that the disadvantages in using coke are fully counterbalanced thereby.

A furnace type suitable for coke as a reducer must, therefore, fulfill the condition that the production of coke-pig from the same kind of ores is at least not higher in cost than if charcoal is used.

The points which are of decisive importance in that case are: Cost of coke, charcoal, limestone and the electric power, as well as the quantities to be produced in each case.

A comparison is made between the conditions at Hardanger, where coke was used, and at Uddeholm and Strömsnäs, where charcoal was employed; the conditions of the comparisons are held to be rather in favor of the Hardanger works. The first one refers to period III at Hardanger and for Strömsnäs for the time from Oct. 1 to Dec. 31, 1912. The second refers to Hardanger period IV and the results from furnace II at Uddeholm from Aug. 4 to Dec. 31, 1912.

The first comparison shows that the ore used in both cases had a high percentage of iron. At Hardanger such ores as Sydvaranger briquets and roasted "red sand" concentrate was used, while at Strömsnäs ores from Kiruna (A), Tuolluvara and Lerberg were used.

The yield of pig iron was: At Hardanger, 69.1 per cent; at Strömsnäs, 65.38 per cent. Consequently the ore used at Hardanger was richer, but as the Hardanger works used coke, a very basic slag was necessary, which lowered the yield of iron calculated in per cent of total material charged to only 56.4 per cent, while the corresponding figure for Strömsnäs was 61.78 per cent, because charcoal was used at the latter place, wherefore less limestone was required.

At Hardanger 336 kg coke and 330 kg limestone was used, while at Strömsnäs 23.58 hectoliters charcoal (the weight of the charcoal is not stated, but the above figure corresponds to about 65 bushels) and 90 kg limestone, all per ton of pig iron produced.

During the same period the yield of pig iron at Hardanger was 2.01 tons per calculated horse-power year, but as the conditions of the furnace were such that this figure is too low, as only about two-thirds of the available energy could be utilized in the furnace, it is to be assumed that 3.015 tons could have been produced per calculated horse-power year.

The cost of electric power, at a price of 33.33 shillings per horse-power year should in that case be 19.18 shillings per ton instead of 28.76 as stated before. The corresponding cost for Strömsnäs, under the assumption that the same kind of ore was used, giving a yield of 69.1 per cent of pig iron, would be 12.96 shillings instead of 13.69 per ton.

The economic results are clearly shown in Table XI.

TABLE XI

| | HARDANGER, PER III | | | STROMSNAS | | | |
|---|---|---|---|---|---|---|---|
| | Kg. | Cost, per Ton | Shillings | Hectolitre | Kg. | Cost per Ton | Shillings |
| Coke....... | 336 | @ 26/8 | 8.95 | ... | ..... | ..... | ... |
| Charcoal...... | ... | . | .... | 23.58 | ..... | @ -/8 | 15.70 |
| Limestone..... | 330 | @ 5/6 | 1.83 | .... | 90 | @ 5/6 | 0.50 |
| El. power ... | .... | ..... | 19.18 | ..... | .... | ... | 12.96 |
| Sum total... | ..... | .... | 29.96 | ..... | .... | ..... | 29.16 |

When the results of Hardanger period IV and the Uddeholm furnace No. II are compared, it is found that the yield of iron from ore was 58.05 per cent at the former and 58.6 per cent at the latter, while the percentage of iron calculated on total amount of charged material was only 41.65 per cent at Hardanger against 52.9 per cent at Uddeholm.

The ore at Hardanger was Persberg and roasted red sand; information as to the ore used at Uddeholm is lacking, but it was presumably Tuolluvara and Persberg.

The coke consumption at Hardanger may be given as about 385 kg per ton of iron (in reality as much as 441 kg was used during the period), but as no gas circulation was used, it is fair to assume that if such had been employed, the consumption would have been about 336 kg, or the same as in the foregoing period.

The consumption of charcoal per ton of pig iron at Uddeholm was 21 hectoliters (about 57.5 bushels) and 186 kg of limestone, while at Hardanger 678 kg limestone per ton of iron was used.

The yield of pig iron per calculated horse-power year during period IV was 1.87 tons. As no gas circulation was used, it may be assumed that this figure could have been increased to 2.2 tons with the gas circulation (see diagram No. 1) and the calculated cost for electric power would have been 28.22 shillings instead of 33.21 shillings.

The corresponding cost at Uddeholm should, if a similar ore had been used, been slightly higher than

TABLE XII

| | HARDANGER, PERIOD IV | | | UDDEHOLM FURNACE NO. 2 | | | |
|---|---|---|---|---|---|---|---|
| | Kg. | Cost per Ton | Shillings | Hectolitre | Kg. | Cost per Ton | Shillings |
| Coke | 336 | @ 26/8 | 8.95 | | . | | |
| Charcoal | | | | 21 | | @ 8 | 13.98 |
| Limestone | 678 | @ 5/6 | 3.76 | | 186 | @ 5/6 | 1.03 |
| El. power | | | 28.22 | | | | 16.82 |
| Sum total | | . | 40.93 | | . | | 31.83 |

---

[1] Teknisk Tidskrift K. O. B., Feb., 1914.

stated (in Table X), namely, 16.82 shillings instead of 16.66 shillings. The results are shown in Table XII.

In Tables XI and XII, a comparison of results is made with ores of practically the same percentage of iron, and under conditions which are in favor of the Hardanger works, inasmuch as all disadvantages adherent to the use of coke are not considered, yet the comparison of Tables XI and XII shows that for these cases and the prices given the smelting with coke was more expensive than with charcoal.

If all factors, such as they appear in reality, are fully considered, we find that the cost per ton of pig iron in the first case is 9.62 shillings higher and in the second 14.23 shillings higher at Hardanger than in corresponding cases at Strömsnäs and Uddeholm.

If the electrode consumption is considered (although it is stated that only 14 kg was consumed per ton of iron during period IV) we find that the costs at Hardanger are respectively 12.42 shillings and 16.56 shillings higher per ton than at Strömsnäs and Uddeholm. Should all disadvantages experienced when coke was used as stated above be considered the figures for the results at Hardanger would be even more striking; in addition to this comes the question of quality of the material produced, a matter which has not been touched at all so far.

According to Mr. Oedquist's opinion, these unsatisfactory results when coke is used must, on the strength of the above, be due to the type of furnace used, at least in the main points.

That better results could have been obtained at Hardanger, if certain alterations had been carried out, is beyond doubt, but judging from the results arrived at in the Hardanger Works, it is evident "*that the furnace such as it was and was operated at Hardanger must be regarded as not suitable for use of coke as reducing agent.*" (Italics by Mr. Oedqvist.)

Regarding the actual reasons why this furnace type should not work satisfactorily when coke is used as reducer, the author of the paper states that not only is the charge very much more compact and presents greater difficulties for the gases to penetrate, also preventing a good and intimate contact between the ore particles and the reducing agent, but still more important is the fact that the great variations in the electric resistance caused by the setting of the charge in the smelting zone, are very detrimental.

These variations extend naturally to the whole system and influence the power supply in such a way that the average load on the furnace for a given amount of available power is considerably reduced, when coke instead of charcoal is used. A direct consequence of this is that the total production and efficiency of the plant is reduced.

When coke is employed instead of charcoal, a much larger per cent of limestone in the charge, on account of the higher sulphur content, is also required. This, of course, causes a direct increase in cost. Furthermore, the charge is diluted with ballast, so that the percentage of iron in the charge is less, which increases the amount of power required for smelting, or in other words, the production is reduced.

Against this stands the fact that the coke is so much less expensive than charcoal, the question is if these two factors counterbalance each other or not.

It would have been of great interest if the author had been able to give the respective costs on the spot of both coke and charcoal, per quantity required in either case. This would have elucidated the case considerably.

What has been said here refers more or less to all furnaces in which electrodes are used and coke employed as reducing agent.

It also shows clearly that the causes for the unsatisfactory results of the smelting at Hardanger were both many and important, and one must not thereby lose sight of the difficulties and drawbacks caused by the type of furnace employed.

On the contrary, the heavily paid-for experience gained at Hardanger should serve to assist in a more satisfactory solution of this great and important question.

That this type of furnace has rendered good results when smelting with charcoal, but proved a failure when coke was used, should on no account be considered as decisive in the question of using coke for iron smelting in general. We must on the contrary fully realize that if electric iron smelting shall occupy the place in the metallurgy of iron, which it is fully justified to attain, it will be necessary to adopt a cheaper reducing agent than charcoal, such as coke or stone coal.

Our endeavors must therefore be to aim at a furnace type which will permit of the use of an inexpensive reducing agent and yet produce a good and even quality, at a price which will stand the strongest competition.[2]

This concludes Mr. Oedqvist's paper. The causes of the unsatisfactory working at this plant should be clear on the main points if the statements made in Mr. Oedqvist's paper represent all the determining factors. This, of course, it is exceedingly difficult to ascertain, as there are bound to be a number of points, which, taken one by one, appear insignificant enough, but in united effect may turn the balance one way or the other. One cannot be too careful in attributing the failure of a plant of this kind to any one specific cause, since there are so many details, which all require a special study.

It is almost unthinkable that such a large plant, involving so many interests, should have been built without preceding trials on a fair scale under conditions as nearly identical as possible. Several furnaces of this type, as is well known, have been working successfully with charcoal, and if the new plant was to work on coke, it seems that the previous working for a few months on coke with the ores in question in one of these already erected plants would have been money well spent, even if it had been necessary to somewhat alter the prevailing arrangements at these furnaces.

Again, if such trials have been carried out, although not mentioned in Mr. Oedqvist's paper, the results obtained, if published, would be of great value as a comparison, and might help to clear up the matter.

It may be argued that the older furnaces mentioned belong to different concerns, who had no interest in the welfare of a new rival plant. But even so, the possibilities of using coke instead of charcoal should have been a strong inducement to carry out such tests, since, as already stated, the charcoal is becoming more and more scarce every year.

As regards some of the difficulties in using coke when smelting electrically in a shaft furnace, the present writer has had opportunity to encounter a few. When carrying out preliminary tests for the Electric Tin Smelting in Cornwall, related in METALLURGICAL AND CHEMICAL ENGINEERING, September, 1911, and elsewhere, a modified kind of shaft furnace was also tried. For certain reasons, coke of various grades was tried in this as a reducing agent. But it was soon found that the results obtained did not encourage a further use of coke under the same conditions. The average working voltage went down as low as 32 to 35 volts, with a corresponding increase of the current, which caused overheating both of transformer, electrodes and other parts. If the voltage was increased forcible arcing took place followed by a volatilization of metal and general disturbance of the running.

---

[2] Correction in the translation in Teknisk Tidsgrift: In Table IV the figure 44.6 should read 41.65. The electrode-diameter given as 500 mm, should read 600 mm in all three plants.

Also, although the total input of power was held at about the same figure as before, the production went down considerably. It was found almost impossible to obtain a satisfactory slag; it was either too viscous or contained a too high percentage of metal.

Instead of "doctoring," however, with the furnace, the use of coke was simply abandoned after a few smelts, since other more suitable reducing agents could be obtained at almost the same price; even had this not been the case, the increased costs when using coke would have justified a more expensive reducing agent.

It shall not be said that coke *could* not be used for the purpose; with correspondingly larger electrodes and allowing for a higher power consumption it is quite feasible that coke could have been successfully used. But the type of furnace *alone* was not the chief fault; in fact, the writer believes that with suitable conditions generally and a different method of working, the same furnace with somewhat larger electrodes would have worked very well with coke, if tolerably free from sulphur. The conditions, however, were such that the use of a more suitable reducing agent became more economic.

Variations in voltage, as stated by Mr. Oedquist, were noted in this instance as well, but in no cases to any such extent as mentioned. On no occasion was a higher tension than 65 volts per phase required at the furnace, even when starting up from cold; though the furnace was, of course, very much smaller, which may to a certain extent account for this fact.

The use of coke, in that instance, had one redeeming feature: the electrode consumption was somewhat smaller, probably because the well conducting coke piled up round the carbons and acted partly as secondary electrodes. But the difference was very slight, and had no appreciable influence upon the economic result, since the heavier slag sometimes formed crusts on the electrode stumps, which made it difficult to use up the butt ends.

One of the chief drawbacks, however, was the low resistance of the coke, which caused the increase in current and a decrease in voltage, also altering the zone of reaction.

Reverting to the iron smelting, Dr. Lyon says:[3] "I have already mentioned the relative value of coke and charcoal as a reducing agent in the electric furnace, that we need more information along this line, and that we expect to get it. It is to be remembered that it has been only two or three months since the plant at Hardanger in Norway shut down because they could not use coke as a reducing agent. In California they have found out the same thing; that is, they cannot use coke alone, due to the high conductivity of the same.

"It is also to be remembered that the iron furnace is a resistance furnace, that the heat is created by the resistance which the charge offers to the current, and that as coke is a better conductor than charcoal, less resistance is offered by the charge when coke is used as a reducing agent, and hence the current consumption per ton of metal produced is greatly increased. However, as before stated, we still need more information on this subject and hope very soon, as a result of some experimental work which we are contemplating, to secure the same."

These remarks corroborate the observations made above, and it will be interesting to see to what result further researches will lead. Some metallurgists suggest to abandon the use of a shaft-furnace altogether; although this would simplify the work in the smelting zone and lead to a simpler design generally in one way, it is difficult to say if the sacrifice of the pre-heating of the charge in the shaft is justified on this account.

Other remedies may be and will be found; so much work and capital has already been spent on this problem that it seems likely that it will be satisfactorily solved in a not too distant future.

## The First Chandler Foundation Lecture

One of the most interesting features of the celebration of the fiftieth anniversary of the Columbia School of Mines on May 29 was the inauguration of the Chandler Foundation lectureship founded in honor of the only surviving founder of the School of Mines, Dr. Charles F. Chandler. The first Chandler Foundation lecturer was Dr. Leo H. Baekeland.

To both a grand reception was given when they appeared in the large and well-filled lecture hall of the Havemeyer Building. Dr. Chandler spoke charmingly of olden times and touchingly of his former colleagues, especially of Eggleston, and then introduced the lecturer of the day, Dr. Baekeland. The title of Dr. Baekeland's lecture was "Some Economic Aspects of Industrial Chemistry."

As Dr. Baekeland's brilliant address dealt in crisp, epigrammatic form with almost anything within the sphere of industrial chemistry, it is plainly impossible to do it justice in abstract. All we can do here is to sketch briefly the leading ideas of the lecture. Publication of the lecture in full is reserved for a later issue.

Dr. Baekeland emphasized the interrelation between chemistry and civilization and showed how industrial chemistry had developed in different directions and at different times in France, England, and Germany. A large part of the lecture dealt with the fixation of atmospheric nitrogen—"en epos of applied science," the economic problem and its different technical solutions—production of nitrate, cyanamide, nitrides.

Many chemists regard a process too much from the narrow viewpoint of the chemical reactions involved and overlook all other considerations. But such "secondary" considerations are often of decisive importance for the commercial success; for instance, the cost of transportation.

This was shown in great detail by Dr. Baekeland by the example of the Leblanc soda process. A very well-worked out process, known in all details, brought to perfection, it is now in languishing agony succumbing to "secondary" considerations. The chlorine industry, its present status and probable future were discussed.

The importance of cheap power in the electrochemical industries was pointed out, but it was also pointed out that cheap power is not everything. The cost of water-power is high in the United States as compared with Norway; further, while the Norwegian water-powers are close to the ocean, the American water-powers are not. The possibilities of gas power were discussed. Dr. Baekeland then turned to agriculture which is "but a branch of industrial chemistry," and to the possibilities of photochemistry.

The completion of the Panama Canal shows what a government by engineers can do, as against a government by politicians. We have still too many men of yesterday. What is needed are men working not for to-day, but for to-morrow.

After the close of Dr. Baekeland's brilliant lecture President Butler presented in a felicitous little speech ("that the punishment may fit the crime") the first imprint of the Chandler gold medal to Dr. Baekeland.

---

[3] Transact. Am. El. Chem. Soc., XXIV, p. 151

# Chemical and Industrial Applications of Mechanical Refrigeration

By H. J. Macintire

In the foregoing articles an attempt has been made to describe only the cycle of the refrigerating medium. Before proceeding to the direct application of mechanical cooling to industries it is wise to consider certain general details, such as the use of a brine (or cold air), of direct expansion, the operating back pressure, etc.

Generally speaking it is more advantageous to use direct expansion. By this is meant that the liquid refrigerant is permitted to pass directly to the cooling system, where it vaporizes and returns to the refrigerating machine. As the condenser pressure is usually about 150 lb. gauge, the liquid refrigerant is carried to the expansion valves in the refrigerating coils automatically (hydrostatically). The conveying pipe can be relatively small and need not be insulated unless the pipe has to be carried through warm pipe shafts or rooms. The return pipe, however, has to be insulated and has to be relatively large. Pressure drop in the suction return line (the difference between the cooling pressure and the back pressure on the compressor) usually must be kept below 5 lb. and this varies directly as the length of the return line, and inversely as a function of its diameter. There are also possibilities of serious breaks in the pipe line, which may be injurious to the goods being cooled, or to personal safety.

With direct expansion it must be remembered that the refrigerating machine must operate when cooling is desired. With a brine or cold air a cooler is placed in some convenient place (usually the engine room itself) and the brine or air is circulated over the cooler and into the rooms to be cooled. This circulation is a forced one, requiring (except in special cases) the continual use of power for this purpose.

Thermodynamically, there is a loss of efficiency in the method, especially where brine is used, on account of the second system of cooling coils. Usually there is required from 4 to 5 gal. of brine per minute or about 500 cubic feet air per minute per ton of refrigeration.

With brine there is a very decided advantage in not having to use the refrigerating machine all the time, refrigeration being obtained by the circulation of cold brine, previously cooled.

In certain industries, where "peak" loads occur a smaller (and therefore cheaper) refrigerating machine may be installed in conjunction with a large brine storage tank—brine being cooled by continuous operation of the refrigerating machine—the temperature of the brine being lowered during the periods of small demand for cooling and raised when the demand on the system is greater than the normal capacity of the machine.

The operating back pressure used on the compressor must not be too low. A consideration of part 1 of this series will show that the operating back pressure determines the temperature at which refrigeration takes place. A decrease of back pressure decreases this refrigerating temperature and the refrigerating capacity of the machine, but increases greatly the displacement of the compressor per ton of refrigeration and the power required from the prime mover. A regulation of the back pressure to suit the refrigerating temperature is therefore desirable.

## Cooling of Liquids

One of the principal uses of refrigeration is in the cooling of liquids, such as water for drinking purposes or for steel tempering, beer wort, oil, milk, brine, etc. These are usually the simplest of all refrigerating problems, as the refrigerating "duty," in tons of refrigeration, is obtained by the product of the pounds of liquid cooled per minute, times the specific heat, times the number of degrees cooled in degrees Fahrenheit, divided by 200.

The specific heat is frequently a variable, as in brine, beer and oil refining The latter case as well as the abstraction of naphtholene from varnish oil, has another detail which must be considered; namely, the congealing and freezing of a solid which is later separated from the oil by means of a filter press—paraffine in the case of mineral oil—and accurate calculations should allow for the latent heat of fusion of this content.

## Cooling of Air

Frequently, in the process of cooling of the fluid, whether it is in the soap manufacture, or the separation of gasolene from natural gas, there is another factor entering into the computation; namely, the latent heat of condensation or of fusion. This is particularly true in the cooling of air—one of the most common applications of mechanical refrigeration to chemical industries—such as the dry blast for blast furnaces, the manufacture of gelatin films, chocolate, etc.

It must be remembered that atmospheric air contains water vapor—an amount depending on the temperature and humidity of the air. As a rule, a lowering of the air temperaturs of 10 to 15 deg. will bring the air to this condition of saturation and still further decrease in temperature will mean the precipitation of moisture, requiring nearly 1000 B.t.u. of refrigeration per pound of water condensed.

Frequently, the air is cooled below 32 deg. Fahrenheit (especially that air near the cooling pipes) and the condensed water vapor is also frozen on the cooling pipes; the frost increasing in thickness until the pipes became practically useless for further cooling until they may be defrosted.

The arrangement allowing frost to freeze to the pipes is obsolete for large installations running continuously, for several reasons. First, there is required considerably more refrigeration in order to freeze the condensed moisture, and second, there is considerable variation of duty obtained from the pipes as well as trouble and expense in defrosting.

A better value for the coefficient of heat transmission and an elimination of the frost is obtained by wetting the cooling coils continuously with some convenient liquid—such as brine. The brine is allowed to fall from one horizontal pipe to another, and finally to a cold basin where a pump raises it up to the top of the coils again. The brine keeps the pipes continually wetted, and absorbs the condensed water vapor—the latter diluting the brine by a like amount.

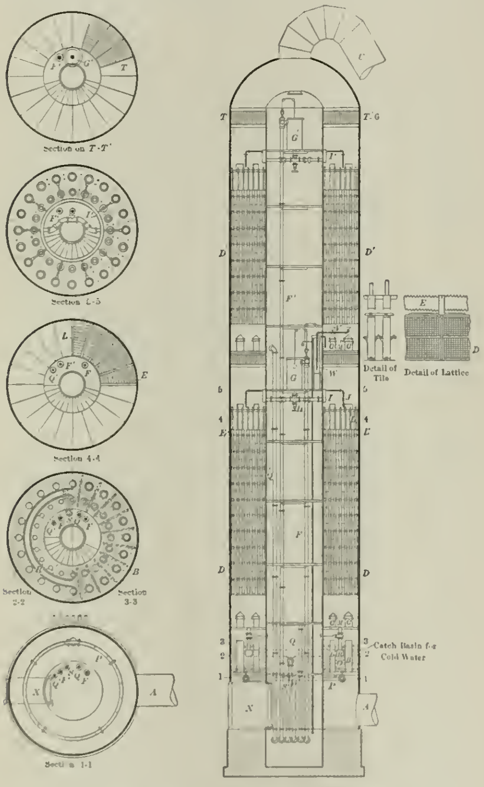
The brine must be strengthened by means of a concentration apparatus like that used in the so-called dry-blast process of the Carnegie Steel Company, or by the addition of more salt.

The illustration shows the former—designed for the cooling of 40,000 cubic feet of free air per minute to 25 deg. Fahrenheit in two stages. In the first stage the air enters under atmospheric conditions and at the base of the tower and is cooled to 39 deg. Fahrenheit, in contact with *water-wetted* pipes. The air leaves this stage at 39 deg. Fahrenheit and contains 35 grains of moisture per pound. In the second stage the air comes in contact with the *brine-wetted* pipes in the upper part of the tower and leaves the tower finally at 25 deg. Fahrenheit and with 19½ grains of moisture per pound of dry air.

A calculation for such a tower for, say, a typical summer day in Pittsburgh, would be for air at 90 deg. Fahrenheit and 86 per cent humidity using a psychrometer chart for the calculations:

(1) To cool 1 lb. air from 90 to 84.8 (dew point) .......................... 1.33 B.t.u.
(2) 84.8 deg. to 25 deg. F. and condense moisture ........................39.8
(3) To cool condensed water for an average temperature of 26.4 deg. F....00.7
41.83

The specific volume of air at 90 deg. and 85 per cent moisture is 14.47 cubic feet.



COOLING OF AIR IN TWO STAGES

Total number of pound air cooled per minute is $\frac{40000}{14.47} = 2764.$

Total refrigeration = $\frac{2764 \times 41.83}{200}$ = 578 tons refrigeration.

It may be added that the dry blast requires considerably less power in the blowing engine than does the common system (as well as a smaller piston displacement) and that the uniformly low water content in the air gives a much cheaper pig iron as well as of better quality of production.

### Shaft Sinking

As a final application of refrigeration may be given that of shaft sinking, excavation or foundation work in ground of boggy or partially fluid condition. Here it is necessary to freeze the vicinity of the work to be performed in order to obtain a zone of sufficient strength to withstand the inward pressure as soon as excavation is commenced.

In shaft sinking of much depth the main difficulty is to drill the holes—within which the brine pipes are placed—sufficiently parallel to each other. Should the drilled holes be out of plum the resisting wall of frozen material may give way. The brine tubes are frequently 4 in. in diameter and are placed about 3 ft. apart. The depth of practical excavation is usually 400 to 500 ft., but depths of 1300 ft. have been attained. As a rule $MgCl_2$ brine only is used on account of its stability in solution as well as on account of its ability to carry low temperature (— 15 deg. F. to — 20 deg F.) without freezing. The time of freezing varies from 3 to 12 months, depending on the size of and condition of the work.

A knowledge of the composition of the material to be frozen must be had if accurate calculations of the refrigeration duty are to be made. The specific heat of dry minerals is nearly 0.2 and the density about 1.8, whereas the water content may vary over a large range. It is usual to figure on a frozen section of 3 ft. on the inside and 1½ ft. on the outside of the circle of brine pipes and a cooled section of about 5 ft. thickness on each side of the frozen area. The calculation of the necessary refrigeration requires a consideration of the cooling of the solids, cooling of the liquid content to 32 deg. F., freezing of this water and finally the cooling of the ice formed. A good rule is to allow an average of 85 B.t.u. per hour of refrigeration duty per square foot of brine pipe cooling surface and to allow about 33 per cent for losses.

University of Washington, Seattle, Wash.

## Copper in Scotland

The high reputation of the British Geological Survey for completeness and accuracy has been impeached through the accidental finding by a boy, innocent of geology, of a piece of copper-bearing ore on the Otter estate in Argyllshire. It appears that the youth found the lump of ore more than eight years ago, and kept it until some two years ago, when he showed it to a mining expert in Glasgow, whose investigations have resulted in the discovery of three fairly good lodes at Kilfinan, Inveryne and Tighenraed.

The Kilfinan lode was found in exploring a barren field which no amount of manuring would induce to grow even a crop of grass and which local tradition described as being under a curse. It is the best of the three finds and is being worked by the Otter Copper Company, Ltd. Shortly after work was begun a vertical vein of copper carbonate, some 2 in. thick, was found; and about 40 ft. further on this vein opened out to a compact mass of gray sulphide from 1 ft. to 2 ft. thick.

The authorities of the Geological Survey have naturally evinced great interest in the proceedings, and have deposited some rich specimens of ore in the Geological Museum at Jermyn Street. Until the discovery was made it was assumed that metalliferous ores did not exist on the eastern side of Loch Fine to the same extent as on the western side; and the geological map shows no copper in that district. So far the mining operations have resulted in 266 tons of the best ore being smelted with an average yield of 15 per cent, together with about 70 tons of dump which gave 3½ per cent. The mines are in the immediate vicinity of tidal waters and there is every facility for economical working and transport.

# Notes on Unit Cost-Keeping in Metallurgical Work

BY JUSTIN H. HAYNES

In the last few years scientific management has become a live issue in all lines of industrial work. Many attempts have been made to adapt the new ideas and systems to mining and metallurgy, but with very little success up to date. Usually the number of clerks required to execute the efficiency idea is prohibitive. The route clerk, the motionstudy clerk, the various supply clerks, etc., almost lead a manager to believe that more men are necessary in the office than in the works.

In all so-called efficiency systems, or schemes for scientific management, great stress is laid upon the necessity of some plan of payment by means of bonuses, but very little information is given as to how this should be done. Time-studies are dwelt on at great length but do not seem to give the desired result. Time-studies are spasmodic and unreliable: spasmodic, because they are made only when the idea so strikes the executive in charge; unreliable, because they usually are made for very short periods of time, giving results which are sure to be either above or below the average. The only time-study that is absolutely reliable of work being performed, is the average of the work accomplished over a long period of time such as a month or a year. Time-study should come later, and will show the small leaks in detail.

## Cost-Keeping Versus Bookkeeping

The whole object of the efficiency movement is a greater production for a less sum of money. This makes cost-keeping one of the most essential points of the system. The mistake usually is made of allowing the bookkeeper or accountant to devise the cost system. Bookkeeping is a function of accounting. Cost-keeping is a function of engineering. The objects of the two are entirely dissimilar; they are looked at from entirely different points of view, and it is next to impossible to combine them. The bookkeeper and accountant must show information of value to the manager, directors and stockholders. He must show the debits and credits, resources and liabilities; he must show the difference between total cost and total income; in other words, he must show whether the property is making a profit or is losing money. In this way he is able to guide the directors as to how much money they can spend on betterments, what dividends can be declared, and similar questions. Cost-keeping is for the engineer or executive and shows in detail the cost of each department and what has been accomplished for the money spent. It is without value unless it aids him in controlling the working details of the property.

Accountants say that cost-accounts must be tied to the total actual expenditure in order to be of any value. Engineers say that cost-accounts must be tied to the work accomplished in order to be of any value. The latter view must necessarily be correct; but preferably, the cost-account should check both ways. Cost-keeping is not an exact science, for large errors creep in at the very basis of the data. A man working eight hours will have his time distributed over, say, five or six departments, and it is impossible to obtain the exact time he spent in each department. This reason alone must make cost-keeping merely a very close approximation; and the fact that an item will vary at the end of the month a few dollars more or less from the actual sum paid out by check does not decrease its value to the executive.

## What the Engineer Wants to Know

The point the engineer does have to know is how much was accomplished for each dollar spent, and usually the books do not take accomplishment into consideration in any way. In fact, cost-keeping as handled by the bookkeeping force is an attempt to fulfill the growing desire for detailed cost, but does not furnish the information that an engineer versed in cost-keeping would give. To know the exact cost of a certain piece of work, and to be able to compare it with other costs for the same work, it must be reduced to a unit basis. The meat of the whole subject lies in the unit system of cost-keeping, and in what unit is used.

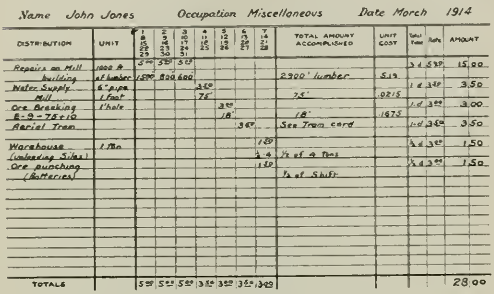
For example, if a new roof is put on a mill building the accountant is interested primarily in crediting the carpenter with one day's work at so much, and later seeing that it is balanced by the debit of the day's pay given to the carpenter. The engineer does not care primarily about the man receiving his pay, but is interested in knowing how many squares of roofing were put on for $1. The engineer must know this in order to compare the cost of this roof with the cost of other roofs under similar conditions, and whether the mechanic was working efficiently or not. The stockholder or director, and therefore the accountant, is not interested in how much this roof cost per square, but is interested in knowing the relation of the total improvements or repairs to the total operating expense. Therefor, in a metallurgical mill where the costs are finally converted into cents per ton, this roof will be classed as repairs amounting to so many cents per ton. Your engineer could not tell from the fact that general repairs on this roof amounted to $1\frac{1}{2}$ cents per ton of ore treated, whether the work was efficiently done or not, but if he knew the cents per square for putting on the roof he could then judge of the efficiency of the work. Thus the value of different units becomes very apparent. If a carpenter puts a new stairway in a mill, which cost unit will best serve the engineer — cents per ton of ore treated, or dollars per thousand feet of lumber? It is unfortunate that most of our cost-keeping systems are inaugurated by accountants.

It is a comparatively easy matter to keep track of the amount of work accomplished per day by miners, trammers, etc. It is not so easy to keep track of the work accomplished by men on shift in the mill, such as battery men, cyanide men, crusher men, etc. This is due to the fact that the latter are on duty merely to watch machinery in operation and see that the wheels keep turning. Therefore special methods have to be introduced for such cases. To keep track of all men at work, with the exception of men on shift, requires merely that the records, in addition to showing the number of hours worked and the rate of pay, must show also the amount of work accomplished, based on some unit.

## Card System of Unit Cost-Keeping

The cards illustrated herewith show how this can be done in the ordinary routine of office work, without requiring extra clerks. After these records have been kept for a number of months, showing the average cost per unit for each line of work, standards can then be obtained from which bonus systems can be very easily calculated, following any of the standard plans desired.

A very important card is that illustrated by Fig. 1, which shows in detail the amount of work accomplished by each man, with cost of work done, and readily allows the latter to be converted into unit cost for each line of work. As illustrated, the card is very satisfactory, but slight changes in its form may be desirable under special conditions. These cards are usually made 5 in. by 8 in., to fit standard filing systems. Each card represents a period of seven days, and four or five cards are required for each man per month. It will be noted that the days of the month are arranged in the style of a calendar, with a check mark opposite the week for which the card is used. By this system a card is complete at the end of every seven days; and if the weekly system of reports is used, the week will always end on the 7th, 14th, 21st, 28, and, excepting February, on the 30th or 31st, giving in all cases, except February, one week containing two or three days. The distribution is left blank on the printed card so that in complicated work any distribution can be inscribed, thus extending the system to as fine detail as is necessary.



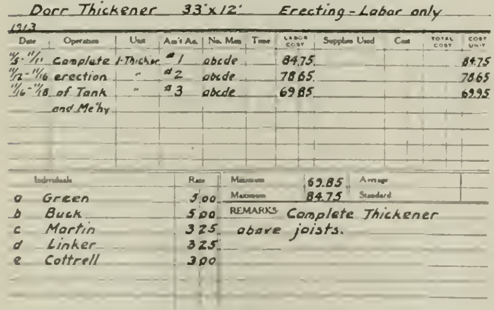
Name John Jones  Occupation Miscellaneous  Date March 1914

| DISTRIBUTION | UNIT | 1 8 15 22 29 | 2 9 16 23 30 | 3 10 17 24 31 | 4 11 18 25 | 5 12 19 26 | 6 13 20 27 | 7 14 21 28 | TOTAL AMOUNT ACCOMPLISHED | UNIT COST | Total Time | Rate | AMOUNT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Repairs on Mill | 1000 ft | $5^{00}$ | $5^{00}$ | $5^{00}$ | | | | | | | 3 d | $5^{00}$ | 15.00 |
| building | of lumber | 1500 | 800 | 600 | | | | | 2900' lumber | 5.17 | | | |
| Water Supply | 6" pipe | | | | $3^{50}$ | | | | | | 1 d | $3^{50}$ | 3.50 |
| Mill | 1 foot | | | | 75' | | | | 75' | .0215 | | | |
| Ore Breaking | 1 hole | | | | | $3^{00}$ | | | | | 1 d | $3^{00}$ | 3.00 |
| E-9-75+10 | | | | | | 18' | | | 18' | .1675 | | | |
| Aerial Tram | | | | | | | $3^{50}$ | | See Tram card | | 1 d | $3^{50}$ | 3.50 |
| | | | | | | | | | | | | | |
| Warehouse | 1 Ton | | | | | | | $1^{50}$ | | | ½ d | $3^{00}$ | 1.50 |
| (unloading Silos) | | | | | | | | ½·4 | ½ of 4 Tons | | | | |
| Ore punching | | | | | | | | $1^{50}$ | | | ½ d | $3^{00}$ | 1.50 |
| (Batteries) | | | | | | | | | ½ of Shift | | | | |
| TOTALS | | $5^{00}$ | $5^{00}$ | $5^{00}$ | $3^{50}$ | $3^{00}$ | $3^{50}$ | $3^{00}$ | | | | | 28.00 |

FIG. 1—CARDS FOR UNIT COST KEEPING

The specimen card illustrated is filled in to cover different rates of pay, different units of accomplishment, and a wide variety in the lines of work performed. Each distribution is allowed two lines. On one of these lines the time is kept as in a standard time-book, except that the time for any certain day is entered in dollars and cents instead of hours. The second line of the same distribution is used for the amount of work accomplished. In this way no time-book is necessary as the cards form the time-book for one week. If it is desired that one card should report a month's work the same plan can be followed except that a larger card is required. The two lines given on each distribution allow for main-distribution, together with a line for sub-distribution.

This card allows the efficiency of each man to be readily calculated; and an average record for several months will give a very clear comparison of his work with that of other men on the job. At the same time it takes practically no more office work to keep a card of this kind, than to keep his time without a unit system of accomplishment. In the case of gang-work in which, say, six carpenters together put up six thousand feet of lumber in one day, it is very difficult to tell the amount each man has accomplished by himself, as his card must necessarily show one-sixth of six thousand feet, or one thousand feet, erected. This is not detrimental to the system in any way, as his unit cost will then increase or decrease with the unit cost of the gang; and the changes in the gang, which are certain to occur from time to time, will give a line on the man's efficiency, even though his work is greatly complicated with that of other men.



Dorr Thickener 33'x12' Erecting-Labor only

1913

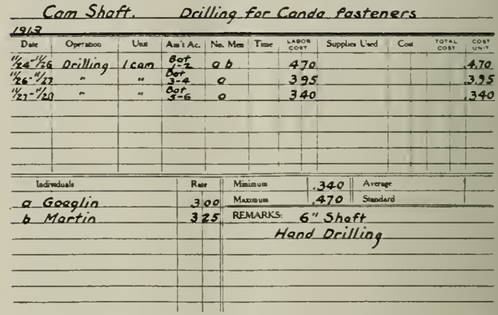
| Date | Operation | Unit | Am't Ac. | No. Men | Time | Labor Cost | Supplies Used | Cost | Total Cost | Cost Unit |
|---|---|---|---|---|---|---|---|---|---|---|
| 11/5-11/11 | Complete | 1-Thickner | #1 | abcde | | 84.75 | | | | 84.75 |
| 11/12-11/16 | erection | " | #2 | abcde | | 78.65 | | | | 78.65 |
| 11/16-11/18 | of Tank | " | #3 | abcde | | 69.85 | | | | 69.95 |
| | and Mc'hy | | | | | | | | | |

| Individuals | Rate |
|---|---|
| a Green | 5.00 |
| b Buck | 5.00 |
| c Martin | 3.25 |
| d Linker | 3.25 |
| e Cottrell | 3.00 |

Minimum 69.85  Average
Maximum 84.75  Standard
REMARKS: Complete Thickener above joists.

FIG. 2—CARDS FOR UNIT COST KEEPING

Figures 2, 3 and 4 show another form of card which is very convenient, as it can be adapted to practically any type of work. As illustrated they are used entirely for checks on the cost of special work, and do not give the exact figure of efficiency for any one man. Nevertheless they are very valuable to the engineer or superintendent as a check on his costs. Fig. 2 refers to a gang of men erecting Dorr Thickeners. This is a card obtained from actual practice, and shows the increased efficiency of a certain gang of five men in erecting these machines. As will be noted the first machine cost $84.75 to erect everything above the foundation joists, including machinery. After completing the first, the gang immediately went on to the second tank and then to the third, showing an increased efficiency as they obtained more experience in erecting the tanks under these conditions. Fig. 3 indicates the same thing, that is, increased efficiency as the men "get into the collar."



Cam Shaft. Drilling for Canda fasteners

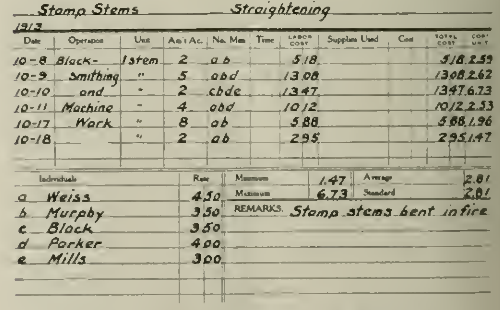
1913

| Date | Operation | Unit | Am't Ac. | No. Men | Time | Labor Cost | Supplies Used | Cost | Total Cost | Cost Unit |
|---|---|---|---|---|---|---|---|---|---|---|
| 11/24-11/26 | Drilling | 1 cam | Bot 1-2 | a b | | 4.70 | | | | 4.70 |
| 11/26-11/27 | " | " | Bot 3-4 | a | | 3.95 | | | | 3.95 |
| 11/27-11/28 | " | " | Bot 5-6 | a | | 3.40 | | | | 3.40 |

| Individuals | Rate |
|---|---|
| a Goeglin | 3.00 |
| b Martin | 3.25 |

Minimum .340  Average
Maximum .470  Standard
REMARKS: 6" Shaft
Hand Drilling

FIG. 3—CARDS FOR UNIT COST KEEPING



Stamp Stems Straightening

1913

| Date | Operation | Unit | Am't Ac. | No. Men | Time | Labor Cost | Supplies Used | Cost | Total Cost | Cost Unit |
|---|---|---|---|---|---|---|---|---|---|---|
| 10-8 | Black- | 1 stem | 2 | a b | | 5.18 | | | 5.18 | 2.59 |
| 10-9 | smithing | " | 5 | abd | | 13.08 | | | 13.08 | 2.62 |
| 10-10 | and | " | 2 | cbde | | 13.47 | | | 13.47 | 6.73 |
| 10-11 | Machine | " | 4 | abd | | 10.12 | | | 10.12 | 2.53 |
| 10-17 | Work | " | 8 | ab | | 5.88 | | | 5.88 | 1.96 |
| 10-18 | | " | 2 | ab | | 2.95 | | | 2.95 | 1.47 |

| Individuals | Rate |
|---|---|
| a Weiss | 4.50 |
| b Murphy | 3.50 |
| c Black | 3.50 |
| d Parker | 4.00 |
| e Mills | 3.00 |

Minimum 1.47  Average 2.81
Maximum 6.73  Standard 2.81
REMARKS. Stamp stems bent in fire

FIG. 4—CARDS FOR UNIT COST KEEPING

### Eliminating Incompetent Men

Fig. 4 shows the cost of straightening stamp stems that were bent in a fire. The costs in this case were bound to fluctuate more or less with the amount of work necessary to straighten the stems. But there is one point that looms up in a very remarkable manner on this card. It will be noted that on October 10th a man lettered "c," whose wage was $3.00 per day, evidently caused an enormous increase in the cost of that day. While the average for the entire time was $2.81 per stem, nevertheless on the day that "e" worked the cost jumped to $6.73 per stem. On investigation it was found that "e" was somewhat of an agitator and decidedly a hard man to get along with. The natural conclusion from this card is that wherever "e" is working he not only accomplishes practically nothing himself, but interferes with the other workmen. It probably would be unjust to discharge him on the basis of this one card, but by switching him around to other jobs and finding the same thing to be true in all cases, it is certainly of vital importance to get rid of him.

These cards, as represented by Figs. 2, 3 and 4, may be used also for checking the work of a certain man; in making time-studies of a certain operation; or in keeping separate certain distributions. These cards are not necessary to a successful system of cost-accounting by various units, but are found to be a great convenience for all lines of special work. If these cards are kept for a period of several months and a file made containing several hundred cards, the information contained thereon will be of great value and extremely interesting.

It is not claimed that these cards are a cure-all for cost-keeping accounts, but the article is written with the primary intention of showing that a cost system must contain both the amount spent and the work accomplished, in order to be of any value to the operator in handling his work efficiently.

Denver, Colo.

## The Construction of the Blast Furnace Stack

By J. E. Johnson, Jr.

In the construction of the blast furnace the conditions to be met are diverse and to some extent conflicting. The efforts to meet these conditions have been almost innumerable, and types of construction of the most various kinds have been used for almost all portions of the furnace. These conditions we may proceed to outline.

### RESISTANCE TO TEMPERATURE

Resistance to temperature is necessary to some extent throughout the furnace, but particularly in the hearth and bosh. The temperatures in these regions in the days of cold blast furnaces were moderate, probably around 2200 to 2400 deg. Fahr., and were resisted with some success even by natural refractories such as sandstone, which sometimes was used for the bottom and for the lining of the hearth and bosh of furnaces, even in coke practice, within little more than a generation.

But with the development of the furnace in the direction of greater output, and the more accurate control of the quality of the metal produced, the requirements have steadily grown more severe. Temperatures in the hearth and bosh in coke practice now probably range from 2500 to 2800 deg., these being the temperatures of the iron and slag as they come from the furnace, but it is almost certain that even higher temperatures exist around the tuyere zone. Probably 3000 deg. is not far from the working temperature prevailing in that zone in many furnaces. This approaches the temperature at which all materials lost a great portion of their resistance. If they do not melt they soften and are easily deformed or abraded.

### RESISTANCE TO CHEMICAL ACTION

The lining of the blast furnace is probably exposed to more diverse chemical conditions than that of any other apparatus in industrial use. Iron itself, particularly before it is completely carbonized, when molten is exceedingly active chemically and will dissolve or react with almost anything with which it comes in contact, especially substances in their elementary condition.

In the early days when sandstone was used as a refractory slags were relatively neutral—that is, they were what would now be called very acid. The requirements were then not nearly so severe in the matter of desulphurization, and as a consequence not much more lime was added than enough to make a fusible slag. But as the demand for a purer product has grown, more and more base has been added to the slag until now its chemical activity in most cases is intense. Few materials with which it comes in contact can long resist its solvent action unless protected by water-cooling and so kept below the temperature at which they can be dissolved.

As we go further up in the furnace we come to the zone in which the cyanides resolve themselves into different chemical compounds of great chemical activity in consequence of their composition and their nascent condition. We have here also an atmosphere consisting almost wholly of nitrogen and carbon monoxide at nearly a white heat initially, which gradually declines as the top of the furnace is approached. The reducing power of carbon monoxide under these conditions is enormous and is reinforced by the presence of incandescent carbon itself in the bosh of the furnace. Therefore, any metallic oxide in the lining which is subject to reduction by either of these agencies would be immediately reduced with consequent destruction of any refractory of which it composed a part. It is probable that many mysterious cases of bad results with fire-brick in the early days of their manufacture were caused by the presence of iron in them, which being reduced by the action of the furnace caused a disintegration of the brick and the early destruction of the lining.

The fume of blast furnace gas which gives the white color to the waste gas from a hot working furnace contains an appreciable quantity of soda and potash; these are liable to be precipitated by the decreasing temperature toward the top of the furnace, and to have a highly solvent action on the silica of the lining when this happens.

When zinc or lead, particularly the former, are present in the charge, even in almost infinitesimal quantities, they are vaporized and have a variety of actions on the lining which is almost incredible to one who has not torn out linings subjected to these conditions, as I have many times done. As an instance of the peculiar actions which this substance has, it may be illuminating to describe what I once saw in the bosh of a furnace blown out for repairs to the upper lining, the bosh being good and left intact.

The furnace was blown down so low that the stock had been burnt out below the level of the tuyeres, and crawling in through a cooler opening as soon as the little material remaining in the hearth could be cooled down sufficiently, I was astonished to see what looked like little stalactites, yellowish white in color, varying in length from two inches to six or more, and about a quarter of an inch in diameter at the base, standing up all over the bosh wall. When touched they fell to pieces and it was with great difficulty that some specimens were taken out whole. They were hollow, with walls only about as thick as wrapping paper, and very light and flocculent. Careful examination showed that they were the oxide of zinc which had been contained in the brick work of the bosh, presumably in some sort of state of solution, until after the pressure of the blast had disappeared. The oxide had then exuded, or more properly perhaps I should say "sublimed" out of the brick into the solid condition, and, being carried upward by the air let in at the tuyeres to cool off the furnace, it formed these little stalactites.

In tearing down the brick outer walls of the older types of furnaces I have found large lumps of crystals of silicate of zinc in cavities in the lining at a distance of four or five feet from the nearest point to the inside of the furnace.

I have seen bricks taken out of the old lining apparently perfect in size and shape but somewhat dark in color. When lifted these would be two or three times the weight of ordinary bricks and if measured up carefully would be found to be half an inch larger in each dimension than the original brick from which they had grown. These were saturated with zinc oxide, which had swelled them as a whole without the least sign of cracking, the bricks being firm and, if anything, stronger than in their natural condition.

These instances are mentioned only to show the vast variety of chemical actions which the lining of the furnace must resist.

### RESISTANCE TO ABRASION BY THE STOCK

About one-half, by volume, of the charge of the furnace in almost all cases is coke, one of the most highly abrasive substances known. In practically all cases also limestone is added to the charge in the condition of lumps sometimes of the size of a man's head or larger, but more generally crushed down at least to go through a 4-in. ring. The balance of the charge is made up of ore which varies from the soft condition of a plastic clay to the condition of one of the hardest of the common rocks, according to the variety. These materials are put through a modern furnace 90 ft. high, at the rate of something like 1700 or 1800 tons in twenty-four hours. The limestone and the ore as they approach the hotter zone are softened if not reduced to powder by the action of the gas upon them, but the coke remains firm and hard until it is burnt up at the tuyeres.

The abrasive action of such a mass of material even at atmospheric temperature would be considerable, but when it is remembered that in the lower portion of the furnace temperatures prevail which are above the softening point of any material available, it is obvious that the abrasion by the descent of the charge alone must present a problem to be reckoned with.

### RESISTANCE TO ABRASION BY THE GAS CURRENT

The velocity of the gas through the shaft is exceedingly high, probably higher than is realized by those who have not actually estimated it. I believe in ordinary modern practice it is never less than 3000 ft. per minute, and more probably double that. This gas is necessarily filled with fine particles of material from the stock, which is in a constant state of agitation due to its descent, so that the fines are swept out of it almost as chaff is separated from wheat. These fines are picked up and carried by this great volume of gas moving at this high velocity. Most of the particles impinge on the solid stock, but many of them strike the furnace walls and exert thereon the action of the familiar sand blast. In this case also we must remember that the resisting material, at least in the lower regions of the furnace, is softened by heat so that much of its resistance is gone, and it becomes evident that we have here a form of destructive energy whose effects cannot be ignored.

### RESISTANCE TO PRESSURE

It is absolutely necessary that the furnace be gas-tight in the same way, and as nearly as possible to the same extent as a good boiler is steam tight. The pressures, it is true, are not as high as modern boiler pressures, but they range from 10 to 30 lb. per square inch in modern practice, probably averaging in Lake ore practice around 15 lb.

The effect of pressure in promoting reaction, especially when gases are concerned, and its effect in giving density and carrying power to the gas currents, are probably factors in the situation, but the principal point is that if this pressure be not resisted at every point gas will find the weak spot, and, traveling through it, will carry heat and chemical action to assist the destructive effect of the pressure. The pressure-resisting quality of the structure comes from the steel shell outside the lining, but this is quickly destroyed if the conditions prevailing within the furnace proper strike it, and with its destruction the whole structure fails. For this reason resistance to pressure is one of the prime conditions to be met.

Had the builders of those tiny furnaces which dotted the central Eastern states in the first half of the last century been shown these formidable specifications in advance of having practical knowledge of the subject they would undoubtedly have thrown up their hands and ceased all efforts to meet such apparently impossible conditions. But, as a matter of fact, they had not the disadvantage of this knowledge, for disadvantage in their case it would have been, since the practice to which they were accustomed involved difficulties constituting only a fraction of those outlined above. This was due to the lower temperatures and the lower rate of driving, with its reduction of abrasion both by gas and by stock, and perhaps most important of all they did not dream of such pressures as we now consider right and proper.

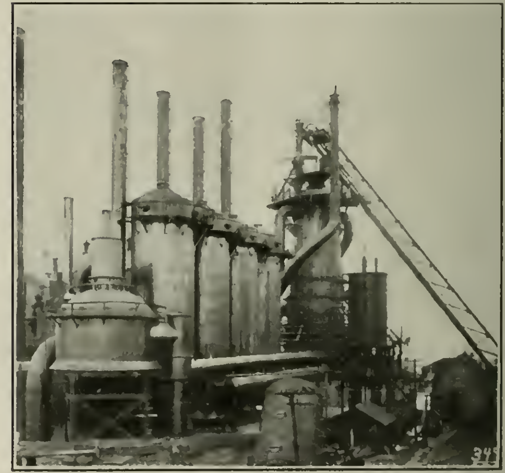


FIG. 1—MODERN BLAST FURNACE STACK WITH STOVES AND DUST CATCHERS. BUILT BY WILLIAM B. POLLOCK COMPANY

In happy ignorance, therefore, of the conditions which their successors would have to meet, they built stacks of stone, truncated pyramids, one side of the base almost as long as the stack was high. In the earliest days all these were built, as I have already described, against and into a hill. Only one tuyere was used. No distinction was made between supporting structure and lining. The stack was simply a truncated pyramid 20 to 40 ft. high, with a hole some

6 or 8 ft. in diameter through it, hardly different from a square chimney with a round flue, except of more squatty proportions. In one side was an archway into the stone work which gave access to the single tuyere and the fore-hearth which I have previously described.

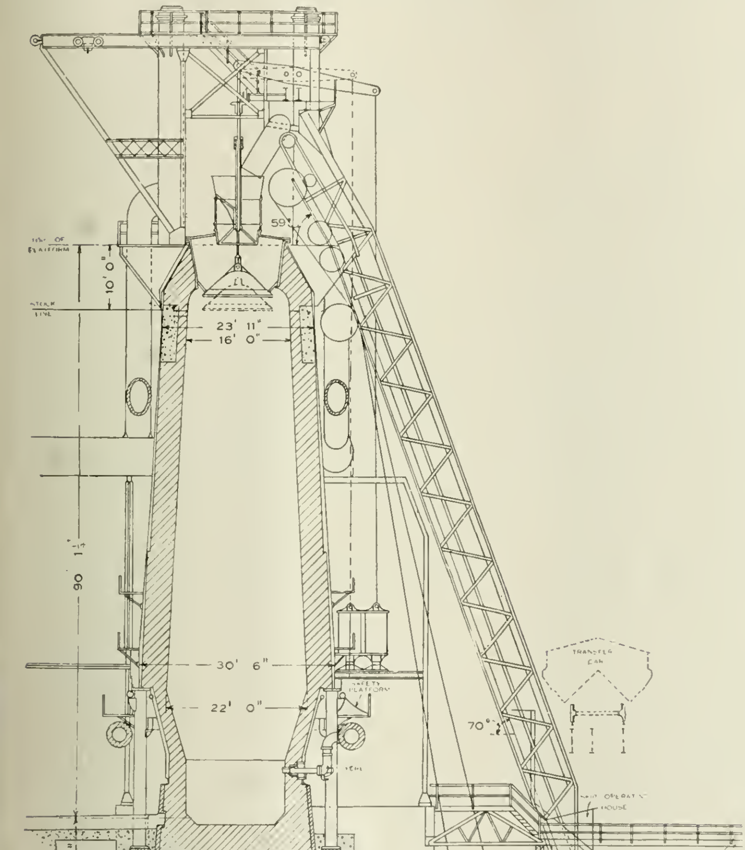


FIG. 2—VERTICAL SECTION OF "A" FURNACE, BETHLEHEM STEEL COMPANY

This simple pile of masonry resisted the pressure of the blast, the heat of the combustion, the abrasive action of the stock and the chemical action of its heterogeneous contents.

The gradual increase in output from those days to our own brought changes in construction, and these in turn permitted greater outputs which again required other changes of construction, and so, with each successful step helping toward the next, and with slow, painful and costly progress we have passed from those primitive conditions to those prevailing to-day.

Two of the earliest changes were the substitution of fire-brick for the lining of the stack and the provision of an archway in each side of the structure with a tuyere in each arch instead of only one. More probably in many cases three of the arches were used for tuyeres; in the fourth the tuyere was left out in order to make room for the fore-hearth, tapping hole, etc. Gradually as the proper shape of the furnace was evolved the hearth structure became separated at the base from the piers of masonry which supported the whole stack, and finally it became evident that it was desirable to increase the distance between these so as to provide greater access to all portions of the hearth. In course of time also the stone stack with its binders of hewn timbers gave way to a brick stack banded with flat bands like a tank, the structure passing from square to round in its exterior shape, the lining being of fire brick and fully differentiated from the stack proper.

About 1860 this structure was superseded at one of the Lake Champlain furnaces by a shell riveted up of plate iron standing on cast iron columns, the prototype of the structure used to-day and lined with fire brick.

The photograph of a modern furnace is shown by Fig. 1. The stack is at the right. A section drawing of another but similar furnace with its hoist is shown in Fig. 2.

It will be seen that there is a foundation of concrete 13 ft. below the ground level and 39 ft. in diameter, upon which the whole structure rests. An annular foundation of brick work upon this supports the bases of the columns, ten in number, each 25 ft. high and 2½ in. thick. Upon these columns rests a heavy ring of structural material better shown in detail in Fig. 3, and to this mantel is riveted the shell of ¾-in. steel plate, 36 ft. in diameter at the bottom and 23 ft. 11 in. in diameter at the top. This shell is riveted up with the same class of workmanship as that used in the best steam boilers. Within this shell is the brick work about 4 ft. thick at the level of the mantel and maintaining nearly this thickness all the way to the top. Below the top of the mantel the brick work is thinner down to the tuyeres and then below the tuyeres thicker again, finally uniting with the furnace bottom, which consists of some 8 or 9 ft. of solid fire-brick work on the concrete foundation.

This structure is in broad outlines typical of the standard construction of to-day, but the variations of detail are almost as numerous as the individual furnaces. It is impossible to describe all these variations individually, but by dividing the furnace into zones we may deal in some detail with the conditions to be met and the approved forms of construction in each. The zones in which the furnace should be divided for this purpose are the hearth and bottom, the tuyere zone, the bosh, the shaft and the top.

### The Hearth and Bottom

The necessity of resistance to chemical action for the furnace as a whole has been briefly described above. This is particularly necessary in the hearth and bottom because these actions are the most intense in that region and because the consequences of failure of these structural parts are so disastrous.

The hearth of a furnace just before the cast time contains normally 60 to 80 and may readily contain 150 tons of molten iron and 20 to 40 tons of slag. The effect of pressure in intensifying chemical action has already been mentioned and in the hearth this condition is exaggerated by the fact that the pressure due to the depth of metal and of slag on top of it, is added to the pressure of the blast which, of course, is highest at the tuyeres. We may have, therefore, a depth of 7 or 8 ft. of metal with 2 or 3 ft. of slag laying over it, exerting a pressure of 3 lb. per square inch for each foot in depth of iron, and about 1 lb. for each foot in depth of cinder, so that we can easily have a liquid pressure of 25 or 30 lb. in the bottom of the furnace in addition to the 15 lb. of blast pressure in one properly working or perhaps 30 lb. in one working irregularly, so that the total pressure in the hearth of the furnace may easily approach 50 lb. per square inch.

If this be not firmly resisted and the least yielding takes place a crack will occur in the brick work and the metal instantly following this crack will approach the outer wall of the structure which supplies its physical strength, and if it succeeds in reaching this at some point not completely protected, the stream of liquid iron will quickly cut a hole through the iron or steel jacket around the brick work, and the stream of metal flowing through this hole will enlarge it with a rapidity which is almost beyond belief except by those unfortunates who have had experience with this action.

In one case which came under my personal experience the stream of iron cut through the hearth jacket a hole elliptical in shape and about 3 ft. long by 1 ft. high, with its long axis horizontal. Even if the hole be many times smaller than this the entire contents of the furnace are ejected through it under the action of their own weight, and the pressure of the blast in a few minutes, and this vast mass of molten material with the tremendous cutting power which flowing streams of such molten material have destroys anything metallic in its path in short order, and in very many cases has cut and seriously damaged the columns supporting the furnace structure. If this runaway body of metal strikes a wet place on the floor of the cast house or on the ground an explosion is almost certain to result which may be disastrous in its consequences. Furnaces have even been put out of blast by the results of such breakouts, and even worse cases are only too numerous in which men around the furnace have been injured or killed by such accidents.

For this reason the construction of the hearth and bottom of the furnace has received an enormous amount of consideration and experienced furnacemen are quite generally of the opinion that any reasonable amount of money spent in securing a construction immune from breakouts is well invested, a conclusion with which I thoroughly agree.

A construction which in general meets this object has finally been developed, and is illustrated in Fig. 3, which shows in vertical half section the lower part of the blast furnace of the Inland Steel Company at Indiana Harbor, Indiana.

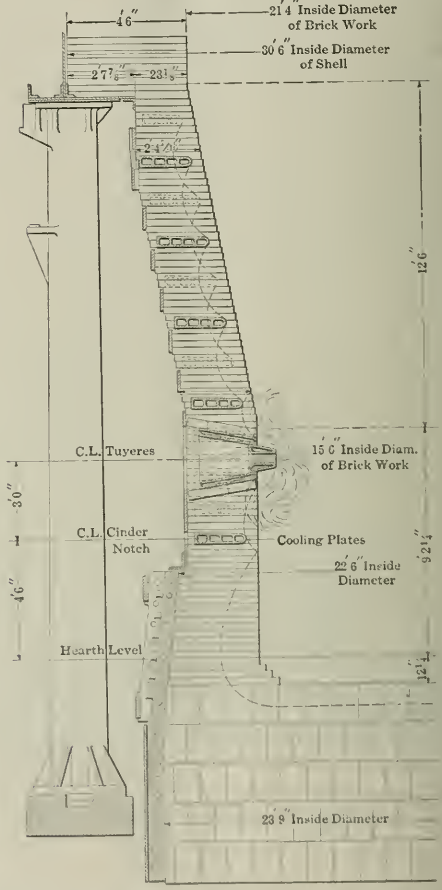


FIG. 3—HEARTH AND BOSH OF INLAND STEEL COMPANY'S "B" FURNACE

The metallic part of the construction consists of a series of steel staves with coils of cooling pipes cast in them, which extend from about 4½ ft. above the bottom level of the furnace to about 6 ft. below it. These are not fastened to each other, but are surrounded by an outside jacket. The lower part of this consists of a heavy rolled steel jacket riveted together with internal and external butt straps, no pains being spared to make the strongest joint possible, this jacket is separated from the staves by a small expansion space filled with yielding material.

The upper part of the staves is surrounded by a cast-steel jacket which also has water-cooling pipes cast in it. Its staves are fastened together by links shrunk onto the projecting lugs. They are of great thickness and, being made of steel castings, are enormously strong, but are further reinforced by rolled steel bands about 3 in. thick by 1 ft. in height around the top and bottom. The edges of the segments of this upper cast steel jacket are carefully planed to make a perfect joint, it having been found by experience that if there be an open joint in the jacket no matter how solidly the brick work may be built inside it, sooner or later the iron is likely to worm its way through the brick work and reach this crack. The instant the iron reaches it and begins to flow through it, the crack enlarges by the cutting power of the metal and soon a full-fledged breakout takes place which nothing can stop until the furnace is empty.

For this reason no pains or expense are spared to make hearth jackets not only strong enough to resist the expansion of the brick work and to prevent their rupture by this action, but also to make them of practically air-tight construction.

It was formerly considered by many furnacemen exceedingly dangerous to have internal water cooling below what is known as the iron line—that is, the height to which the iron may rise in the ordinary course of operation—this height being normally some 2 or 3 ft. below the center of the tuyeres, though in case of trouble the iron may rise up to the tuyeres. The reason for this objection to water-cooling is that a current of iron flowing with considerable velocity will cut a water pipe or other cooling apparatus with the water flowing through it, since it is impossible for the water to remove the heat as fast as the stream of iron supplies it. When a cooling member is cut in this way explosions are almost certain to occur, and these are more disastrous the more confined the location in which they take place. Many frightful accidents have occurred through the cutting of water-cooled parts by molten iron.

When the joints in the outside jacket are absolutely tight such a flow of metal cannot start, and as it is only a flow which possesses this tremendous cutting power, the cooling pipes are not endangered by this action when there are no crevices through which the iron can flow past them. By the combination, therefore, of the tight jacket, and the water-cooling staves inside it, the danger of breakouts which formerly was almost the worst dread of the furnaceman's life, have been reduced to a minimum, almost to a negligible quantity.

It will be noticed in Fig. 3 that there is a thickness of three feet of brick at the top of the hearth jacket, and that this increases toward the bottom. This is for the reason that the high velocity at which the blast is injected through the tuyeres gives it a mushrooming effect indicated in Fig. 3, which throws it back against the wall around the tuyeres and tends to cause severe cutting, augmented by the heat and chemical activity of the molten iron and slag. These jointly tend to cut away the hearth as shown in dotted lines, but by having an ample thickness of brick and having the line of water-cooling of a much larger diameter than that of the nose of the tuyeres, the water-cooled surfaces have a better chance to overcome this combined action, so that furnaces built in this way cut back to a certain distance and then stop, whereas if the outside diameter of the hearth were made smaller in relation to the tuyere diameter the probabilities are that it would eventually give way under the joint attacks of these three influences.

It was formerly thought that every furnace had to have one or two breakouts when it started to working properly soon after it was blown in, and in the days when furnaces were small and the quantity of iron in them at one time was only a few tons, this, while a bad condition, was endurable, but, as furnaces and their outputs have grown and the amount of metal released by a breakout has increased, it has become increasingly necessary to solve this problem almost irrespective of the cost of the construction. The evolution of the general type described is the result of necessity.

### THE DITCH AROUND THE HEARTH JACKET

There is ordinarily a ditch around the outside of the hearth jacket extending from just above the base of the columns, which are bricked in solid, up to about a foot above the hearth level, and practice in regard to this ditch has varied greatly. It is customary to use this to carry off the waste water from the tuyeres, coolers, etc., and formerly these ditches were kept full of water to their tops, with the idea that this furnished effective cooling of the hearth jacket and tended to prevent breakouts. But in order to keep the ditch full of water its outlet must be dammed, and when this was done if a breakout did occur the molten iron filled up the ditch to the level of this dam, part way or even all the way around the furnace, and when cold had locked itself between the columns and the hearth jacket, whence it was almost impossible of removal.

At one time the practice prevailed of filling the ditch to the top with large lumps of limestone piled in as loosely as possible, then if a breakout occurred the decomposition of the limestone by the heat and the subsequent slacking of the lime tended to crack apart the mass of iron, which, of course, was much reduced in quantity and solidity by the presence of the lumps themselves. This practice is an improvement, but the practice of carrying the ditch full of water is itself going out of vogue to some extent, and personally I would never have the water in the ditch more than a couple of inches deep if it could be avoided. This enables the ditch to be kept open to the bottom, and if a breakout occurs the molten iron will run out the outlet and leave the ditch comparatively free. Moreover, more effective cooling may be obtained by the spray from a small circle pipe causing a thin film of water to trickle down over the hearth jacket than can be obtained with a large body of standing water. This has often been established and is another illustration of the principle that rapid circulation has as much to do with heat conduction as the amount of surface and conductivity of the material involved.

Allowing the outlet from the ditch to carry off the iron in case of a breakout has some disadvantages because the iron itself will run along the bottom of the ditch underneath the water for long distances, even in quite small quantities. I have known it to go 60 or 70 ft. and plug up the screen over the waste opening into the sewer so as to create a fearful nuisance.

To meet this situation two expedients are available, one of which is extremely simple and should always in my judgment be used. This consists in having an auxiliary outlet from the ditch normally kept closed and designed to discharge at some point sufficiently removed from the furnace so that any iron carried off by it may do as little harm as possible. This ditch may be closed either by a hand-operated gate or by a thin lead plate. The latter will cut off the flow of water effectively, but will melt in case iron strikes it and open up the emergency outlet. This should preferably be placed lower than the main outlet so as to drain the iron completely away from the latter. The use of this expedience once saved a shutdown of many hours at a plant formerly under my management.

The other expedient is somewhat more expensive. It consists in building a large chamber or cistern in the bottom of the outlet ditch, which is covered over by the cast house floor plates under ordinary conditions, and stands full of water all the time, the wastewater current simply passing across its top, but if a breakout occurs the iron will run into this cisterm and has to fill it up before it can go on through and make its way into the outlet sewer, the plugging of which constitutes a calamity of no mean order.

It is frequently customary to have the ditch around the furnace interrupted by a solid structure of brick on which the iron-trough beneath the tapping hole is supported, but I do not like this construction, as the heat is drawn through the hearth jacket by the poulticing action of this brick pier and the circulation of water is cut off by it. Moreover, in case of a breakout the presence of this dam in the ditch prevents the iron from draining away in that direction and may result in permanently filling the ditch with a mass of iron at that point.

By riveting a pocket a little larger than the outside of the iron trough air-tight on to the front of the hearth jacket the trough can be set down into this and a joint made between the two with cement, the water can then rise practically to the bottom of the iron trough without any danger of getting into it, and yet have an absolutely free circulation around the base of the hearth jacket at this point, which probably needs it more than any other.

### The Tuyere Zone

This is the zone between the top of the hearth jacket and the bottom of the sloping bosh. Various styles of construction have been adopted for this, as for all the other regions of the furnace. One of these which had much vogue at one time was the use of a heavy cast-iron or even cast-steel tuyere jacket with cooling pipes cast in it, and with openings cast through it of the size required by the coolers, no internal cooling by cooling plates being used.

This construction and all others which depend on external cooling in this zone are in my opinion faulty for the reason that the tuyeres must project a considerable distance into the furnace. If they did not, what I have called above the mushrooming effect would rapidly destroy all the parts adjacent to them; therefore, we have first the hollow-walled cooler as a sort of second line of defense which projects into the face of the brick work. Then fitted into this and projecting about a foot beyond it we have the tuyere itself, its nose being some 3½ or 4 ft from the exterior of the brick work, which is literally on the firing line.

The mushrooming effect of the blast, if this zone were without any but exterior cooling, would soon eat away two or three feet of the face of the brick work, which would leave the heavy coolers carrying the tuyere without adequate support. This in turn would allow them to drop down so that instead of directing the blast in horizontally, as they should, it would be blown downwardly into the bath.

To overcome this and to protect the zone around and between the coolers from this intense mushrooming effect, cooling plates are used as shown in Fig. 3. These are hollow plates of copper, or copper with one or two per cent. of tin to make it cast more readily, with a taper in the vertical plane, as shown, and also in the horizontal plane. These are supplied with water from the water-cooling system and a constant circulation kept up through them the same as in the tuyeres.

They are built into the brick work, but on account of the taper above mentioned can be withdrawn by means of lugs provided in their rear or outer surfaces for that purpose. These have a great cooling surface and corresponding protective power for the brick work around them. They increase the resistance of the brick against the action of the fire, and the brick to a great extent protects them from the direct attacks of the latter, although frequently they are directly exposed to it, as are the tuyeres, but able to resist because of the activity of the water-cooling, in exactly the same way that the fire box of a locomotive is able to withstand the intense combustion of the fire within it because the thin plates which constitute its inner surface are so completely cooled by the water around them.

It will be seen that these cooling plates with their ability to withstand the direct action of the fire, protect the fire-brick work underneath and around the coolers from the attacks of the iron, the slag and the mushrooming effect of the blast, and so enable these to maintain their correct position throughout the campaign.

In order to supply the element of strength against the internal pressure of the furnace two constructions are possible. Either bands can be passed around the furnace just above and just below the cooler openings, leaving the space between these bands unprotected, or the bands may be connected by vertical buckstays which protect the intermediate space. The construction which I like best of all, however, is to make a solid jacket of steel plate, as shown in Fig. 3, with the flange at the base resting on the top of the hearth jacket, with holes cut through it at the points where the cooler openings and the cooling plates come. This supplies the means of holding all the brick work to its place, which is necessary, for, in the absence of such protection, it is surprising how small a mass of unbound brick work will detach itself from the rest and work out of the furnace under the action of expansion, pressure, etc.

### The Bosh

This divergent cone which begins at the top of the tuyere zone has received attention at the hand of a vast army of engineers and furnacemen, and many solutions of the problem of a suitable construction have been attempted. The divergent shape of this portion of the structure and its relative lack of solid foundation upon which to build a patch if it fails, combined with the scouring action of the blast traveling up it, and of the semi-reduced iron and scouring slag travelling down it, have made the problem of maintenance of this part of the furnace a difficult one.

One of the most commonly used constructions is that shown by the upper portion of Fig. 3. It consists of several rows, in this case eight, of cooling plates, those in one horizontal row alternating in vertical location with those in the rows above and below it. In other words, the plates in each of the eight horizontal row are not vertically above one another, but are staggered for reasons of mechanical strength, because the plates are very much weaker against compression stresses than the brick work, and if they were all in one row might be crushed by the expansion of the boshwalls due to the heat. By having them in alternating rows larger masses of brick work intervene between them, making a sort of series of arches which do not readily crush. Moreover, if all these cooling plates were arranged in vertical rows, the brick work between these being relatively without protection would be scoured out by the erosive actions I have mentioned.

By staggering the plates vertically the space between a pair in one row is protected to a great extent by the plate in the other rows above and below that space. This construction is shown in Fig. 4. Just above the bustle pipe portions of two rows of cooling plates and their vertical staggering may be quite clearly seen.

The cooling plates must be protected from the weight of the brickwork above them and this is done by one of two methods. Either a flat arch is turned in the brickwork above them or a cast-iron box is built into the brickwork which projects in from the outer wall about one-half or two-thirds the length of the cooling plate, which is inserted through and protected by this box. Both methods are good but the brick arch is much cheaper and just as good for all practical purposes, so is to be preferred.

Circumferential strength is supplied by very heavy bands of steel running around the bosh between the rows of plates. This makes a good strong substantial construction, but in addition to being very expensive on account of the great quantity of copper castings required, it is liable to one serious fault. This is that the erosional influences I have mentioned cut out the brick work between the plates and leave the noses of the latter sticking out into the furnace almost like a flight of steps. I have tried to illustrate this action by the dotted lines in Fig. 3 and can state most emphatically that the conditions shown by this sketch represent only a fraction of the erosion that I have seen in actual practice after a campaign of only a year or two.

When the action has proceeded to the extent indicated or further, the shelves formed by the projecting noses of the cooling plates make ideal lodging places for half molten slag and such materials as it cements together, and such a mass builds up on the noses of the plates at times with considerable rapidity. Then a change in the condition of the furnace comes about or the accumulations are no longer able to maintain themselves on the narrow footing offered by the cooling plates, but in either event the whole mass sloughs off into the hearth and having no time to be treated by the heating and reducing action of the ascending gas is precipitated into the hearth in a half raw condition with resulting ruin to the iron and slag already formed therein, and the partial chilling of the furnace, perhaps to a serious extent.

It is these steps and the consequent irregularity of the work of the furnace at times which has led some furnacemen to abandon this type of construction for one whose wearing surface should be smoother and more regular. This result has been sought in some cases by building up a water-cooled bosh jacket of cast-iron segments as shown in Fig. 5. These segments as shown are strongly bolted together to supply the necessary strength to resist the pressure, and then receive a thin lining of brick, its thickness depending upon the opinion of the furnacemen as to what is necessary, but commonly from nine to eighteen inches. This is an expensive construction and requires careful machining throughout, because if the least crack exists the gas will blow out through it with destructive effect and on account of the crack being small it is almost impossible to get anything in the nature of a clay stop to stay in it.

A third type of construction consists of a bosh jacket made entirely of steel plates and cooled solely by external sprays. This can be made an absolutely airtight job of boiler work, thus eliminating any possibility of gas leakage such as I have described, while the cooling by means of a continual film of water on its exterior surface produced by sprays is one of the most efficient forms which can be obtained in any way whatever, a much greater surface being exposed to the

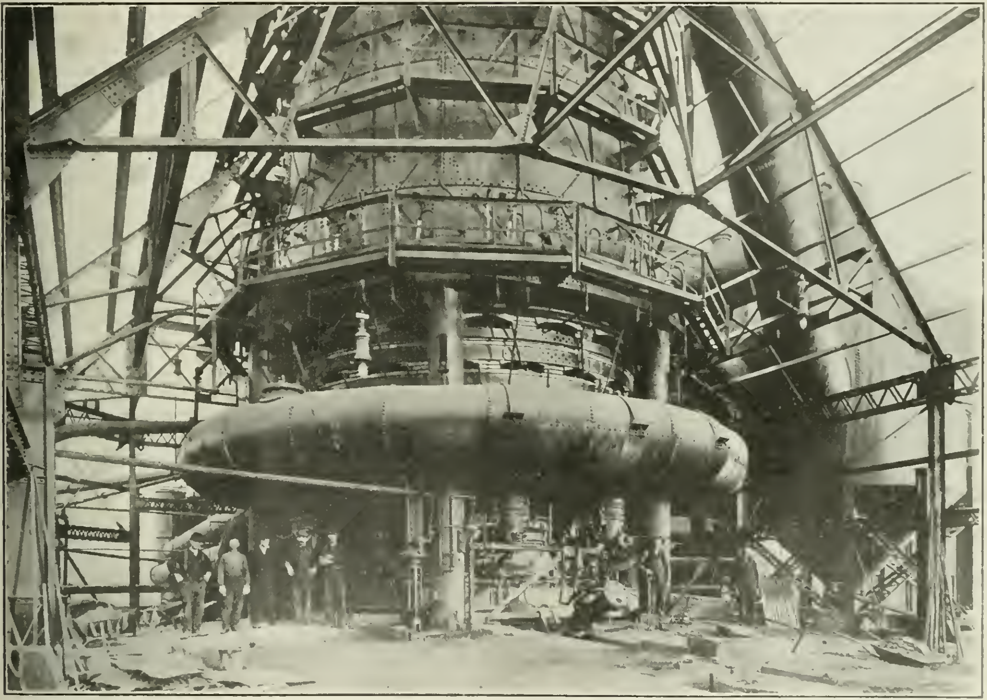


FIG. 4—LOWER PORTION OF FURNACE SHOWN IN FIG. 1

cooling action of the water than in the case of the cast-iron built-up jacket.

One feature of a jacket of this kind must receive the most careful attention. It must be as near absolutely smooth as it can be made by good workmanship. The rivets must be countersunk on the outside and driven down absolutely flush so that a film of water will travel over their heads without any interruption, and in general everything must be done to remove even the slightest obstruction from the path of the water film, because this film travels down the surface with a considerable velocity and even a minor obstruction will throw it off leaving a dry spot below the obstruction. This dry spot becomes hotter than the rest of the jacket and causes contraction strains and in time cracks result, while if it be a large one the lining on the inside of the jacket will melt off and the jacket itself will then be exposed to the assault of the streams of iron and slag running down inside it, which will soon cut a hole through it. Such holes are almost impossible to stop without a long shutdown on the furnace to enable a patch to be put on, and as this can only be done with patch bolts it is never anywhere near as good as the original jacket.

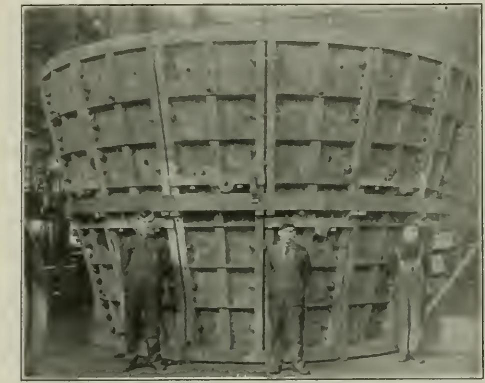


FIG. 5—SEGMENTAL BOSH JACKET BUILT BY BIRDSBORO FOUNDRY & MACHINE COMPANY

This is one of the places where an ounce of prevention is worth a ton of cure, and the only proper course is to make it impossible for a dry spot to form on one of these jackets.

Fig. 6 shows a furnace reconstructed according to the plans of the writer with a jacket of this type in which absolute smoothness was obtained by welding it up with an oxy-acetelyne burner, then chiselling off the roughness at the joints and grinding it down smooth, an operation which took little time and cost a relatively small amount, something like a couple of hundred dollars above the cost of boiler work.

This jacket was flanged out at top and bottom to avoid the necessity of riveting angles on it to make connections to the mantel plate above and to the trough at its base. By flanging the metal out bodily these riveted joints are avoided.

Water is sprayed into the top of this jacket by a circular spray pipe divided into eight sections, each of these being connected to the water supply separately, and each of them also being in duplicate, only one being used at a time. If one becomes obstructed or fails the other can instantly be put on. This feature, as a matter of fact, is used only when it is occasionally necessary to clean out one of the sections, but it is a convenience at that time and contributes to safety at all times and is well worth the trifling expense.

Some care should be taken to supply the water to these sprays under a very moderate head and make the holes in the spray pipes fairly large. They are then much less likely to become obstructed by small threads of pump packing and like and can be made to deliver the water exactly at the top line of the jacket with a minimum of spattering, the water thrown on to the jacket flows down it in a smooth film and the spatter is caught by the annular funnel shown about half way down the jacket, which is not riveted to the latter but comes in contact with it through a serrated edge at the bottom of the funnel. This serrated edge gives sufficient flow at every point around the circumference which would not be the case if the bottom edge of the funnel were straight as the contact would be close enough in that case to cut off all flow in places.

By having the funnel hung from above by independent hangers it is possible to adjust the location of its bottom edge in relation to the jacket with small wedges to regulate the flow and get it uniform around the furnace, which could not so readily be done if the two were rigidly connected. Moreover when the funnel is supported from the jacket this involves rivets in the jacket for the funnel brackets and below these rivets it is almost impossible to avoid having a dry spot as above described.

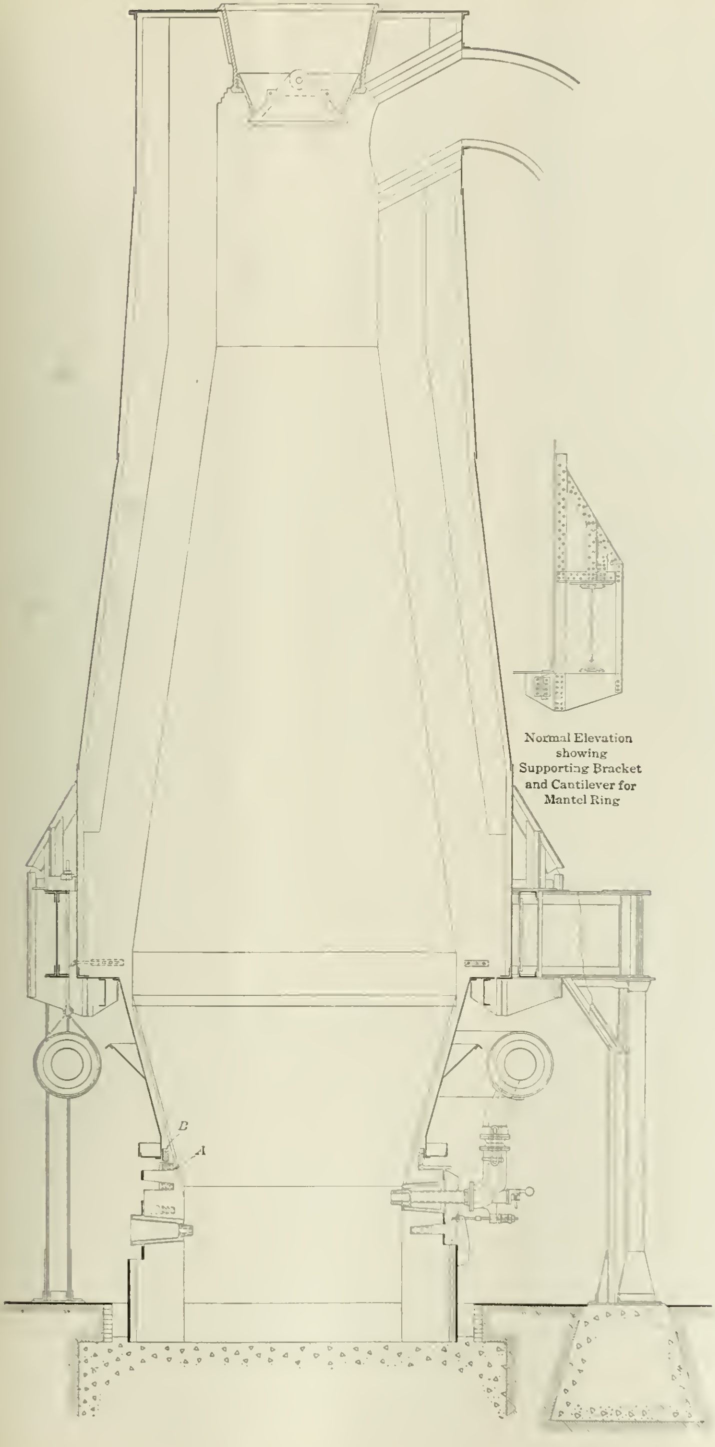
This jacket was so extremely smooth and worked so admirably in service that the intermediate funnel could probably have been dispensed with entirely by widening out the bottom trough a little more and perhaps putting some flanged extensions around its upper edge to catch spatter.

The trough as shown projects out beyond the base of the funnel, but should have been made three or four inches wider than it is because some of the drops from the bottom edge of the funnel are deflected from the vertical line by capillary attraction and fall outside the line of the trough which cause disagreeable spattering down below.

When using a construction of this type it is not only possible but far preferable to use a very thin brick lining in it, because the brick being cooled only from the outside will rapidly wear down to that thickness at which as much heat is carried away from their bases as the currents of molten material and gas supply to their front surfaces. This is only a few inches and if three feet of brick were to be built inside such a bosh jacket in the course of a few months it would all be gone down to a few inches, exactly the same as if it had started at one foot or even nine inches in thickness. Consequently if the furnace were the correct shape to begin with it obviously could not be so with three feet of brick scoured off the bosh all around, therefore the thing to do is to put in only as much brick in the first place as the furnace may be expected to leave there after it has settled down to regular work.

In coke furnaces using a bosh of this type I have several times used only nine inches of brick with very satisfactory results, and in the furnace shown by Fig. 6 which was to use charcoal and therefore much easier on the lining than a coke furnace, I used only four and one-half-inch bricks made up specially as circle bricks to fit the curvature of the bosh. This furnace was blown out on account of commercial conditions after a campaign of about a year and a half, and two inches of the original brick was still left. The judgment of the furnacemen was that it was as good as new.

A point about this construction which must not be overlooked is that the lining in this portion of the furnace is practically self-renewing. If the brick were



Normal Elevation showing Supporting Bracket and Cantilever for Mantel Ring

FIG. 6—CHARCOAL FURNACE, SHOWING STEEL BAR JACKET CONSTRUCTION

all scoured off the jacket clean by bad slag or bad work of the furnace, and the water-cooling were maintained, within a few hours the furnace would have built back itself a lining of slag, carbon dust, etc., just as resistant for its purposes, if not more so, than the fire-brick initially used.

This condition arises from the fact that this portion of the furnace converges toward the bottom, and that any material chilled on it tends to stay because of its conical shape. This is a feature of much importance which does not exist in any other portion of the furnace.

Owing to the small quantity of brick in the lining of the bosh in this construction it is without much compressive strength and differs in that respect from the cooling plate construction of Fig. 3 in which a considerable portion of the weight of the furnace structure is carried on the hearth and bosh walls when the latter are heated up by expansion. With the steel-plate bosh construction this must not be allowed to happen as the thin brick lining would quickly crush and the steel jacket buckle with disastrous consequences under compressive stress. It is necessary, therefore, to provide a sort of expansion joint in which the expansion due to the heating of the brick can be taken up without objectionable consequences. That is accomplished in the present construction by making the lower portion of the bosh jacket proper, cylindrical and putting inside it a set of cast iron water-cooled housings or blocks through low opening in which project cooling-plates as shown at A. These cast-iron housings and the cooling-plates are supported on the heavy brick structure around the tuyeres which extends up from the bottom. The bosh jacket and its lining on the other hand are practically suspended from the mantle.

When expansion takes place the cylindrical portion of the bosh jacket slides down over the water-cooled housings, and if the lining is cracked or broken by this action, the crack is at once sealed by cinder running down over the surface and chilling against the housing and the bosh jacket.

In order to avoid the necessity of lugs and fastenings on the housings they are held together by the band B around their tops, this band being protected from burning by the cold bosh jacket just outside it and the water-cooling within the housing.

The water pipes for the cooling blocks A were brought out at the bottom so that the maximum of expansion could take place without shearing off these pipes, which has been known to happen in a construction of this kind where this provision was not made for it. Even in this case it would have been better if the space between the bottom of the trough and the top of the solid brick wall had been made three or four inches higher.

The water-cooled *housing* and the cooling plates projecting through them perform a double function, they protect the *tuyeres* and coolers below them for the scouring action of the streams of iron and cinder and prevent the spaces between the coolers from being scoured out and so weakening the tuyere zone. Secondly they form a water-cooled shelf at the foot of the bosh slope which supports the lining of the latter and forms a ledge on which a new lining can start to form in case the old one is scoured off by irregular furnace work.

Both these functions are of great importance and some portion of the construction to perform them must be supplied if this type of bosh is to give the long and useful service of which it is capable. When properly designed there is no doubt that this type of bosh construction will give absolutely satisfactory results in furnace operation on account of the perfectly smooth slope of its working surface and the complete absence of steps on shelves, at a cost of construction which is literally only a small fraction of that of the cooling plate or water-cooled stave construction.

*(To be concluded)*

## Colorimetric Estimation of Gold in Cyanide Solutions

It sometimes happens that conditions of precipitation are disturbed temporarily, and frequent determinations of gold in barren solution are desirable in order to control the precipitation process. Time is not available for the ordinary assay, and a rapid method is required which can be performed by the foreman or shiftman in charge of the work. In discussing a paper on the metallurgy of the Homestake ore, presented to the Institution of Mining and Metallurgy by Messrs. A. J. Clark and W. J. Sharwood,[1] Mr. Charles B. Brodigan recorded such a method devised by Mr. Dowsett, reduction officer at the Brakpan mines, South Africa.

With slight modifications, the method of Mr. Dowsett has since been adopted at the Homestake mill for testing barren solution, and we are advised that by its use the mill foremen are able to detect with surprising accuracy variations of 1 cent per ton, in solutions carrying from 1 up to about 15 cents per ton. Seven minutes is sufficient for a test, and the method is extremely useful when conditions of precipitation are unsettled and frequent determinations necessary. No standards are used, the grade of solution being estimated by the depth of color obtained. The color for a 1 or 2-cent solution is very faint, but is readily detected after a little practice. For successful work it is important that the cyanide solution used be of the highest possible strength.

In his original contribution Mr. Brodigan states: "If gold is present to the extent of 0.02 dwt. (2 cents) per ton of the original cyanide solution a very slight coloration will be perceived in the liquid; 0.03 shows a slight yellow; 0.04 slight pinkish-yellow; 0.06 strong pink; 0.08 the purple of Cassius."

### The Method

Details of the method as employed at the Homestake are as follows:

*Reagents required.* Zinc dust, sifted through 200-mesh sieve.

Hydrochloric acid, concentrated C. P.

Nitric acid, C. P., 1 acid; 2 water, in dropping bottle.

Lead nitrate, saturated solution, in dropping bottle.

Sodium cyanide, saturated solution.

Tin chloride, about 12.5 per cent crystals + 10 per cent concentrated hydrochloric acid.

Place about 500 cc of the sample to be tested in a light-colored, sample bottle having a very slight shoulder; a quart beer bottle is about the right size. Add a measured quantity, 10 to 15 cc, of saturated sodium cyanide solution; two or three drops of saturated lead nitrate solution; and from 1 to 2 grams of zinc dust. One gram of the dust usually will be found sufficient. Stopper the bottle with the thumb and shake violently for at least two minutes, or until the precipitate is completely coagulated and will settle rapidly.

Invert the bottle over a casserole and allow the precipitate to settle. Remove the bottle and decant the clear solution from the casserole. Add hydrochloric acid to the precipitate, drop by drop, until the reaction ceases, and then add a few drops in excess. Add three to five drops dilute nitric acid, heat and evaporate to a volume of 1 or 2 cc. Transfer the solution to a small (½-in.) test tube, cool, and add about 1 cc tin chloride. A purple color indicates gold.

With low-grade solutions the tube should be allowed to stand a minute or two to bring out the full color. Faint colors may be seen better by looking down the tube. Some variations in the amount of cyanide, zinc dust or lead nitrate may be necessary with different solutions. The lead should be kept down as far as possible, using the minimum that will give a precipitate that settles rapidly, as this will require a minimum of nitric acid. Too much nitric acid may interfere with the production of the final color. Mercury also gives a dark coloration, and somewhat affects the color given by gold.

**The extension of flotation** to the treatment of disseminated copper ore is indicated in the report that the Nevada Consolidated Copper Co. will install a flotation unit for experimental purposes.

**Progress at the new mill** of the Alaska Gold Mines Co. is said to be satisfactory. The steel for the coarse crushing unit is practically erected, and the roll and concentrating sections are under way. Concrete for foundations in the roll plant has been poured at the rate of about 300 yd. per day.

**The smelter smoke nuisance** is not confined to the western states. Residents of Staten Island, N. Y., have succeeded in having indictments returned against a number of New Jersey smelting and refining companies, charging them with maintaining a nuisance detrimental to public health and property. The court and counsel for the defendant companies have indicated their desire to effect an amicable settlement.

**Refining of platinum** is performed in the San Francisco branch of the Bureau of Mines by boiling the metal, about 75 grams at a time, in a cupel heated by an oxy-acetylene flame. The metal thus refined is softer and more pliable than before the treatment.

---

[1] *Transactions*, I. M. M., Vol. XXII (1912-13), p. 190.

# Three-Metal Bronzes

BY ALLMAND M. BLOW

A great many of the commercial bronzes and the trade-named bronzes, which are really brasses, contain added metals besides copper and tin, either for the beneficial properties derived from such additions, or because impurities are present which do not seriously affect the alloy under working conditions. The last is not true for impurities such as sulphur and oxygen; whereas iron, frequently present in small quantities in spelter, is a beneficial impurity, and special means are often taken to alloy it perfectly with bronze. Among the principal metals added to bronze are lead, zinc, phosphorus, manganese and aluminium, and as such they comprise a group of special bronzes or three-metal systems, in distinction to the regular copper-tin alloy. In addition, a number of commercial alloys are sold as bronze, when they are really of a zinc base. In general, the higher price demanded for bronze and the excess price of tin over zinc to the manufacturer, is the cause of this. Before going into the effect of other metals on bronze a brief outline of the true copper-tin alloys will suffice.

## Copper-Tin Alloys

Fig. 1 is the familiar copper-tin temperature-composition diagram as originally worked out by Heycock and Neville. Other investigators claim a few slight variations from this curve, but for the most part it is generally accepted. The portion *B C c d* is the disputed area, wherein additional changes are claimed to take place.

At any temperature and composition above the line *A B C D E F* copper and tin form a homogeneous liquid. A decrease of temperature to this line (liquidus) immediately starts the freezing out of certain constituents of that liquid, depending on the composition. The line *A b c d g h i j F* (solidus) likewise indicates the completion of the solidification. An alloy of a certain composition, at a temperature above the liquidus, will, on cooling to room temperature, go through certain reactions at the horizontal and curved lines, and contain such constituents as are included in the vertical lines.

The series contains two solid solutions, alpha and beta, and three compounds CuSn, $Cu_3Sn$ and $Cu_4Sn$. The former are true solid solutions of tin in copper as they are homogeneous in structure throughout. The eutectic, or alloy of lowest freezing point, is at 1 per cent copper. A change in the solid state, or eutectoid point, occurs at about 25 per cent tin. The alloys containing high copper are of the greatest importance and as the percentage of tin increases the alloy becomes brittle and therefore of less use. However, at about 80 per cent tin the alloy is practical but contains too much tin to compete profitably with other alloys of equal properties. The usual alloy does not contain more than 25 per cent tin and up to this composition there are two general classes, *i.e.*, tin from 0 per cent to 12 per cent, sheet bronze and gunmetal; and tin from 10 per cent to 25 per cent, bell-metal. Considering the diagram from left to right, solid solution alpha is obtained up to 10 per cent tin. From this point to 25 per cent tin an alloy on cooling will freeze out alpha when reaching the line *A B*. The liquid remaining will follow this line down to *B* where at 795 deg. C. there will be alpha of 10 per cent tin and the liquid of 25 per cent tin. A reaction then occurs whereby solid solution alpha + liquid *B* — solid solution beta. Beta will form as long as both of these are present and the alloy will finally solidify completely when one or the other is used up. Decreasing amounts of tin from 25 per cent will cause the liquid to be used up first, leaving more alpha in proportion to the decrease toward 10 per cent. In any case, the alloy is solid at 795 deg. C., and then further lowering of the temperature caused the beta formed (22 per cent tin) to pass down the line *c e*, which is accompanied by the formation of a little more alpha until the eutectoid point at 500 deg. C. is reached. Here a further change takes place by the breaking down of beta into a mechanical mixture of alpha and $Cu_4Sn$, or the eutectoid. On the other side of this point, beta will throw down one or both of two compounds instead of alpha. Above 32 per cent tin, $Cu_3Sn$ will form first from the beta and at 580 deg. C. a reaction produces, $Cu_4Sn$. From 25 per cent up to 32 per cent tin the latter will form first, and as before, at 500 deg. C. the eutectoid of alpha and $Cu_4Sn$ will cease the changes.

The rate of freezing and cooling will affect these compounds and solutions to a great extent, both in their composition and structure. Alpha, according to the diagram contains nominally 10 per cent tin in solid solution. Long annealing will increase this to 12 per cent without the eutectoid appearing, whereas in the practice of casting, the eutectoid may be seen when only 6 per cent tin is present. The eutectoid contains $Cu_4Sn$ which is hard and brittle and is therefore not generally desirable. Gunmetal, according to the previous classification is then all alpha. For a combination of strength, elasticity, toughness and ability to withstand shock, alpha is the most desirable. Other metals increase these properties; but a true bronze containing 9 per cent tin has the following values:

| | |
|---|---|
| Tensile strength | 32,000 lb. per sq. in. |
| Elastic limit | 13,000 " " " " |
| Elongation in 4 inches | 14 per cent. |

Since no transformation points are passed in the annealing of alpha bronzes, they are practically uninfluenced by heat treatment. But as the tin content is increased more of the eutectoid is present and the alloy comes into the class of bell-metals, which are hard or soft, and will have different tones depending on the amount of $Cu_4Sn$ content of the eutectoid. These alloys above 12 per cent tin are very susceptible to heat treatment. By quenching from above 500 deg. C. (formation of the eutectoid) the eutectoid is partially prevented from forming and the alloy is more malleable by containing beta.

Tin up to 32 per cent produces an increasing amount of $Cu_4Sn$, until just at 31.8 per cent pure $Cu_4Sn$ is obtained. This alloy is given the name of Speculum metal because of the high polish it will take, thus adapting it to minor uses. It is very brittle. A mixture of $Cu_4Sn$ and Cu Sn is obtained in the range 31.8 to 38% tin.

The solid solution beta breaks up into the eutectoid when slowly cooled so that equilibrium is established. However, in this range of composition the alloys are much influenced by heat treatment and quenching. The microstructure of an alloy quenched from within this range shows that some of the beta is retained in the final metal. By treating in this way, the most beta is retained in alloys from 22 per cent to 25 per cent tin, and consequently the final state will consist of beta, alpha and the eutectoid in varying amounts. Beta is desirable to increase the tensile strength and for that property only it is more suitable than alpha. An alloy containing 22 per cent tin, treated so as to get the most beta, will have a tensile strength of about 40,000 lb. per sq. in. The other values are low. Alpha will increase the ductility at the expense of tensile strength, hence a balance must be obtained between the two.

Above 32 per cent tin brings the series into the range of $Cu_3Sn$ and CuSn, alloys containing which have little strength and seldom enter into the three-metal bronzes. At 80 per cent tin the useful properties are somewhat regained, rising from around 2000 lb. tensile strength in the middle of the series, to about 7000 lb., when the strength again decreases.*

### The Effect of Lead on Bronze

In most cases the addition of one metal to another gives a lower mutual freezing point, hence it follows that lead should have a decreasing effect on the temperature changes of the copper-tin diagram. This is found to be the case; and because of the soft nature of the lead and its much lower freezing point than that of a bronze of 10 per cent tin, the resulting alloy is softer, and, on account of these properties the name of "plastic bronze" is applied to this type. By discussing the equilibrium diagrams first, a clearer understanding of the physical properties may be obtained when the lead varies from maximum to minimum.

Fig. 2 shows the temperature-composition diagram of copper and lead. These two metals belong to the class of alloys that are incompletely soluble in each other in the liquid state and completely insoluble in the solid state. The curve given is generally accepted as correct by the many investigators of this alloy. An eutectic point is at practically pure lead (99.94 per cent) at 326 deg. C. Within the dotted half-circle there are two liquids corresponding to 10 per cent and 65 per cent copper; without it, there is a single homogeneous liquid. A copper-rich alloy will freeze out copper to start with when the temperature is lowered so as to strike the line *Cu G*. The liquid is robbed of its copper until at 950 deg. C. it contains 65 per cent at the point *G*. Then further freezing out of copper causes the formation of the second liquid containing only 10 per cent, and the temperature remains constant until no more of the first liquid remains. One liquid is formed at the expense of the other and copper is precipitated. When the reaction has continued to the point *H* then, and only then, will the temperature fall by freezing out more copper from the 10 per cent liquid, the final solidification being at 326 deg. C.

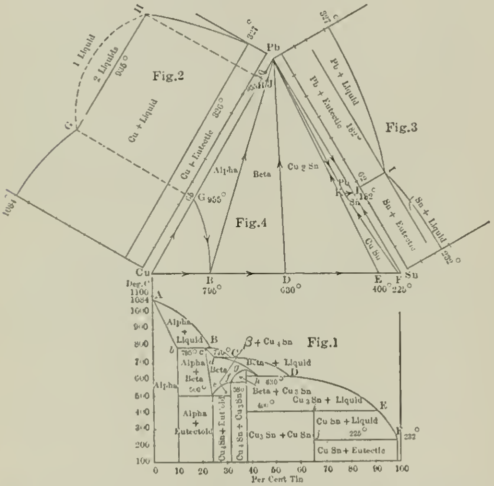


FIG. 1, 2, 3 AND 4—TEMPERATURE-COMPOSITION DIAGRAMS FOR COPPER-TIN, COPPER-LEAD, LEAD-TIN AND TERNARY

Lead and tin (Fig. 3) form a very simple curve with an eutectic point at 62 per cent tin and 182 deg. C. On either side of this point, as the case may be, lead or tin will freeze out first until the liquid is enriched to the eutectic composition; then the alloy will all go solid by the precipitation of this mechanical mixture of lead and tin, the eutectic. Under favorable conditions of cooling, a small percentage of lead (say 3 per cent) may be held in solid solution by the tin; and likewise for tin in lead.

By combining these three diagrams, Fig. 4, the ternary is obtained in which temperature is normal to the plane of the paper and the lines within the triangle represent projections to the horizontal of the intersections of the surfaces of the solid figure. Since each corner of the triangle represents 100 per cent of one of the metals, a surface connecting adjacent sides at this corner and projected on to the horizontal as an enclosed area, will include the first substance to freeze out when all three metals are present, should the composition of the alloy happen to lie within this enclosed area. Thus the area *Cu GB* shows that with copper and tin, alpha forms first; with copper and lead, copper is the first precipitant; but instead of having the two the excess copper produces more alpha, so the result is alpha alone in this area. Beyond the solubility of tin in copper to form alpha, other compounds are introduced represented by other areas, and the intersections mark the change from one to another. The arrows indicate the slope of the projected surface intersections.

A few of the internal change points of this ternary diagram, as to temperature and composition, have been determined accurately by early investigators, notably the direction and slope of the line *G B;* but as to the other parts of the figure there seems to be a lack of authoritative information. Consequently this figure is presented in the way of predicting the results we hope to obtain later, and, while the lines within the diagram will not, with our present knowledge, indicate accurately the limits in composition of the constituents, they will serve to enclose an area in which certain compounds and solutions exist.

Thirty per cent of lead in bronze is about the practical limit. Hence the lower left corner of the ternary is the most important. In the area *Cu GB*, alpha will freeze first. The line *G B* shows that as the temperature falls and this area is intersected, alpha is thrown out and the liquid follows the surface down on a line through the corner, then the saturation point (along *G B*) of the first liquid (originally 65 per cent copper) is reached sooner and at a lower temperature with increasing amounts of tin. This fact is to be noted later in connection with segregation, but since the copper-rich liquid still freezes out alpha to form more of the second liquid *H* (which gives alpha also), there is no interference with the formation of alpha, so it is likewise the first solid to form in the entire area, *Cu Pb B*. The line *H J* is similar to *G B*, marking the beginning of freezing of alpha from the lead-rich liquid. Final freezing takes place at 326 deg. C. when the lead separates out. The alpha formed by the above reactions follows the changes as described before. First will occur the reaction to form beta, then at 500 deg. C. it will give place to alpha and the eutectoid. The line *B Pb* represents this beta-forming reaction.

When there is sufficient tin in the alloy this line will be met on cooling and the liquid will follow it in the direction of the arrow, forming beta. Of course, the composition determines whether the alloy will all go solid before this line is reached; but as the tin increases above 10 per cent the conditions are more favorable and then the beta reaction continues along *Pb B* until no more liquid remains. In the area *G H J B*, at an elevated temperature, are the two liquids:

---

*The strength values given throughout this paper cannot be used for rigid comparison even with alloys of similar composition. Chilled and cast test bars of the same metal, and pieces of the same bar will often give varying results. Standard testing methods are still being discussed.

mentioned before and it is safe to assume that the copper-rich liquid predominates over the other in furnishing beta to a bronze around 25 per cent lead, if only because it is the first liquid to form. The reaction alpha + liquid $G$ = beta will continue until there is no more alpha or liquid, but the latter will evidently be exhausted first as it is being consumed by the formation of the second liquid, and besides, more alpha is being furnished. Consequently as a source of supply the liquid $G$, even being rich in copper, does not allow the beta reaction to progress very far. The other liquid, $H$, having a high lead content, has a depressing effect on the reaction line, hence its slope is toward *Pb* as the liquid is enriched in lead, and the beta precipitated from it is thrown out at a constantly falling temperature. The beta furnished by this liquid is little for the ordinary percentage of lead in bronze; but in any case beta freezes out as the liquids follow the line *B J*. When the liquid reaches $J$ a rapid reduction in temperature takes place with a small change in composition of the liquid. Finally at *P b*, if the liquid has not all been used up by the above reactions, the alloy becomes solid at 326 deg. C.

*B Pb C* encloses an area in which beta is the first solid to form should the composition of the alloy lie in this area. By precipitating this solid solution the liquid is changed in composition until it reaches the line *D Pb*, which represents a similar reaction to that at $B$ whereby beta + liquid = $Cu_3Sn$. This reaction continues as the liquid follows *D Pb* as long as both constituents of the reaction are present. If beta is used up before *P b* is reached the liquid will freeze further as in the next area. As before, at 326 deg. C., the freezing of lead will complete the solidification. Similarly the next line, *E Pb*, denotes the formation of CuSn from the liquid and $Cu_3Sn$, the latter being the first to freeze in the area *D Pb E*. Again, *E Pb F* gives CuSn as the first solid to be thrown out of the liquid. Should the composition of the alloy be such that in cooling the liquid reaches *F K*, there will be a reaction between the CuSn and the liquid to form tin, the composition of the liquid passing down the line to $K$. When the liquid is exhausted the alloy goes solid, but should it hold out until $K$ is reached a further reaction takes place: CuSn + liquid $K$ = solid lead + solid tin, giving the ordinary eutectic of lead and tin. Solidification continues down to $I$ as long as the liquid supplies the reaction. In a like manner *Pb K* represents the simultaneous freezing of CuSn and lead (instead of tin) and at $K$ the above reaction occurs again with the liquid and CuSn. In the area *Pb I K* lead freezes first, in *FKI Cu* tin, and along *K I* the eutectic of lead and tin. The point $I$ is the binary eutectic of lead and tin and also the eutectic of the system.

The effect of lead on the physical properties and microstructure of bronze is for the most part simple. At times a fourth metal is added to make the desirable properties more pronounced; this addition and the rate of cooling are factors very influential on the structure of the alloy, so there is usually a departure from the normal constituents shown by the diagram. Lead and copper form no compounds or eutectic (the 0.06 per cent Cu eutectic not considered) consequently no compounds or solutions of these two metals are found in the alloy when the cooling is slow. Under normal conditions the only difference between a high and a low-lead bronze is the amount of lead distributed throughout the mass after solidification, the lead merely retarding the final freezing to 326 deg. C. and giving the alloy the property of plasticity. Microscopically plastic bronze shows black patches of lead set in the ground mass of bronze (alpha and eutectoid), and in this respect it differs from most anti-friction alloys. The ground mass is harder in this alloy than the included particles. The application of this type of bronze is almost exclusively as a bearing, and for heavy work it is widely used.

The experiments conducted by the Pennsylvania Railroad are responsible to a great extent for our knowledge of the behavior of lead bronze under working conditions. For a long time the limit of lead was 15 per cent; more than this caused difficulties in the preparation of the alloy. This difficulty was segregation and the ternary diagram easily explains the reason. First, consider copper and lead alone. With lead from 35 per cent to 90 per cent, there are two liquids from which the crystallization starts, and these being of a different specific gravity there is a separation or segregation in the liquid state. Then there is an unequal distribution of the solids crystallized from these liquids. On the other hand with lead up to 35 per cent there is only one liquid from which the freezing starts and this trouble is reduced immensely as regards this particular cause of segregation. While an alloy with the percentage of lead as in the last case was more productive of good results than with more lead, still a good casting was difficult to produce because of the too rapid cooling. Then it was found that by introducing tin a more homogeneous product was obtained and this is explained by alpha taking the place of copper alone. However, in the early practice the amount introduced was small because of the further observation that the lower the tin (consistent with homogeneity) the more lead could be added to the copper. Here again the diagram furnishes an explanation by the more recent experimental determination that the 35 per cent saturation point decreases with the addition of tin, so that as this metal is added the outside limits of the two liquids are extended and segregation is more likely to take place. So far, the early difficulties with this alloy are explained by the diagram, but by refinements in the mixing, casting and heat treatment, the old limit of lead, beyond which poor results were obtained, has been increased so that 30 per cent is not uncommon now. By the mechanical manipulation of alloy making, solutions and compounds are often made to change their limits; but since a diagram cannot be made to cover all the various practices, one must be adopted that represents the changes under normal conditions and when equilibrium is established.

Segregation has been the cause of the failure of many alloys. But now that recent knowledge shows the cause for this the trouble has been successfully overcome, not so much by varying the proportions of the constituents, but by the proper handling of the alloy while being compounded, and having the best properties to start with. By learning from curves and thermal diagrams what will be produced for a given mixture, it is easier to foresee trouble and avoid it.

Among the addition metals found to aid in preventing this trouble, the principal ones are nickel, sulphur and phosphorus. One per cent of nickel is said to improve a lead bronze so that with unskillful handling good results and little sweating are obtained with lead at 30 per cent. Copper and nickel are quite soluble in each other in the solid state, so nickel has the effect of producing more alpha solid solution in addition to the regular copper-tin alpha. Also under certain conditions it might be all dissolved in the copper-tin alpha. By a somewhat different method sulphur (added in the form of galena), also decreases the probability of segregation. $Cu_2S$ is formed and the dotted half-circle enclosing the two liquids is flattened toward *G H*. The alloy "Allen Metal" contains sulphur as $Cu_2S$. Phosphorus affects the alloy in a different way. This metal is very often associated with lead bronze and alone with copper constitutes another class of bronze that will be dealt with later.

Phosphor-lead bronze shows, in addition to the other constituents, varying amounts of the hard compound $Cu_3P$, which in a measure offsets the softer patches of lead. It is not often desirable to counteract the softening effect of the lead, because a soft bearing metal that will take the wear is better than a hard mixture that wears the journal. But phosphorus causes a good casting to be made from the alloy and therein lies its principal advantage. For a number of years the standard bearing-metal used by the Pennsylvania Railroad for its car journals was of this composition: 79.7 per cent copper, 10 per cent tin, 9.5 per cent lead and 0.8 per cent phosphorus. The more recent tests caused the adoption of a metal higher in lead and lower in tin on which the comparative wear was some 13 per cent slower than the first standard phosphor-bronze. This metal has the composition: 76.8 per cent copper, 8 per cent tin, 15 per cent lead and 0.2 per cent phosphorus and shows about 24,000 lb. per sq. in. tensile strength as against 30,000 lb. for the old standard. Another discovery is the successful substitution of arsenic for phosphorus. The tendency since then has been to increase the lead more and more and now the alloy commonly sold under the name of "plastic bronze" contains 30 per cent lead, 65 per cent copper and 5 per cent tin. This alloy is very satisfactory, and stands up well even in heavy locomotive bearings and for cars of the largest capacity. A compressive strength of 15,000 lb. per sq. in. is claimed for it, but it has excellent anti-friction qualities.

Other than for bearing metals, lead affects bronze by giving it superior machining properties, and also the appearance of aging or so-called "Patina," a dull bronze polish appreciated in bronze statuary.

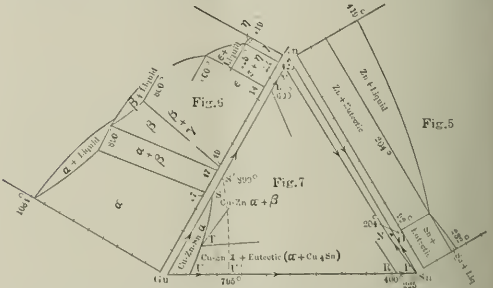
### The Effect of Zinc on Bronze

This phase of the subject could just as well be termed, "The Effect of Tin on Brass" and if so considered together the entire field of brass and bronze is included. Whereas others have written books on the history, physical properties and preparation of these two alloys, the ordinary metallurgist is not fully enlightened regarding their constitution. The microscope establishes at once the fact, the explanation and the proof of the constituents of brass and bronze, and the once dark secrets of alloy making are now being illuminated by the modern scientific searchlight. It is the purpose of the writer to illuminate a few of these dark points; but more important to the chemist and the average metallurgist is a brief description of the most prominent characteristics of brass and bronze, their appearance and the reason therefore. As mentioned before the subject is very extensive, and to deliver this kind of knowledge it would be best to follow the first heading of this division and further limit the discussion to high-tin bronze, with a few words about the other end of the series. Not that other compositions are not important but only bronze is under consideration here and the scope of this paper does not allow further elaboration.

Copper and tin is the base of the ternary (Fig. 7) as before. Zinc and tin (Fig. 5) form a very simple series without compounds and solid solutions. An eutectic point is at 8 per cent zinc and 204 deg. C.; to the left the solid alloy shows zinc and the eutectic, while to the right, tin and the eutectic are present. On the other hand zinc and copper (Fig. 6) give a brass consisting of a number of solid solutions depending on the composition. The series is more complicated than copper and tin, and there is less agreement among allographists as to the points of temperature and composition change, especially in the middle of the diagram. Consequently the two ends will be dealt with here; besides they are more important than the middle values. Three solid solutions are worthy of special notice: epsilon, of 14 per cent copper; beta, of 2.5 per cent copper, and alpha, of 37 per cent zinc.

First, a few of the principal constituents of this class of bronze.

The point of lowest temperature of the ternary is the eutectic of zinc and tin at 204 deg. C. The area *L M N* includes the solid solution epsilon (14 per cent copper) as the first solid to freeze, while the liquid is enriched until the line *M N* is reached. This is followed while the liquid plus epsilon gives solid beta, which with copper and zinc alone occurs at 425 deg. C (Fig. 6) and it is similar to the beta reaction in bronze. Should the liquid be exhausted before *N* is reached the alloy will go solid upon exhaustion, but if epsilon is used before the liquid, the liquid freezes further as in the next area *M Zn ON*. In the event both are present to allow the liquid to reach *N*, there occurs the reaction epsilon plus liquid *N* equals solid beta plus solid tin, which continues until final solidification.



FIGS. 5, 6 AND 7—TEMPERATURE-COMPOSITION DIAGRAMS FOR ZINC-TIN, ZINC-COPPER AND TERNARY

In the area *M Zn ON*, beta solid solution freezes first until the liquid reachese *N O* when beta and tin are precipitated side by side, similar to the ordinary eutectic. Finally the solidification is completed at *O*, the binary eutectic point.

CuSn freezes first in the area *R N P* and when the liquid reaches *N P* there will be a simultaneous freezing of CuSn and tin. At *N*, should the liquid reach there, will occur the same reaction as above with CuSn in place of epsilon.

The area *NO Sn P* yields tin as the first crystals and as before along *N O* the beta-tin eutectic completes the freezing.

As an example of a commercial alloy in the above areas one of the Lumen Bearing Company alloys of about 85 per cent zinc, 10 per cent tin and 5 per cent copper, is illustrative. This solid alloy shows dendrites of epsilon, the first to freeze, surrounded by envelopes of beta, which formed along the line *M N*, and small streaks of beta plus tin in the ground mass produced by the reaction at *N*.

Again Parsons' white brass, which may be represented by the composition, 30 per cent zinc, 65 per cent tin and 5 per cent copper, shows beta and epsilon as before, but a much greater proportion of the eta-tin eutectic ground mass, as the excess liquid allowed the reaction at *N*, and the formation of the eutectic along *N O*, to progress much further. The eutectic being softer than the other constituents, the alloy containing the most, as in the last alloy, will have a softer ground mass and less hard dendrites. Here is the difference in structure between this type of bronze and lead bronze. When the copper content increases several per cent above 8 per cent in a high-tin bronze, and 14 per cent in a high-zinc bronze, $Cu_3Sn$ and epsilon with little beta are introduced respectively. The former is detrimental to a good bronze and it is usually formed unwillingly by being included in the kernels of CuSn and thereby stopping the action which should continue (and does on slow cooling) until all the $Cu_3Sn$ has given place to CuSn.

Now in the general run of this type of bronze the copper jumps to above 80 per cent when the zinc is low. The intermediate percentages between 8 per cent and 80 per cent are seldom encountered for the reason that the compounds found in this range are mostly brittle. A great many alloys have their compositions in the area *S U Cu*. From Fig. 6 it is seen that the copper-zinc solid solution alpha is present up to 37 per cent zinc, and from Fig. 1 the copper-tin alpha up to 10 per cent tin. Therefore, *S U Cu* encloses an area in which there is present the combined solid solution, copper-zinc-tin alpha; that is, in the solid state, as copper-tin alpha is precipitated from the liquid state up to 25 per cent tin, but upon cooling gives the eutectoid, so that to give alpha only, the limit is 10 per cent (normally). The same is true for copper-zinc alpha which freezes first up to about 45 per cent zinc, but in the solid state copper-zinc beta may be introduced if the zinc is much above 37 per cent. The second line *S′ U′* shows the limits of alpha when freezing from the liquid. The point *T* may be taken as the dividing point between brass and bronze. On the zinc side, copper-zinc beta throws the alloy into the brasses. On the tin side, the presence of the eutectoid determines the alloy as bronze. The area between encloses a mixture of the two.

Consider, for example, an alloy of 88 per cent copper, 10 per cent tin and 2 per cent zinc. Normally this composition is just on the line of separation beyond which the eutectoid appears. The zinc is all in the solid solution alpha because it is a value far below the saturation point of zinc in copper. Slow cooling produces homogeneous grains of alpha, but if the reaction, alpha plus liquid equals beta, is not allowed to be complete the grains are surrounded by some eutectoid formed from beta, and the two will appear as concentric circles. Of course, this alloy is practically identical in structure to ordinary bronze; the zinc changing alpha only slightly. Also, the physical properties are not altered much, a slight gain in tensile strength and ductility being apparent as a result of the zinc.

With more zinc another class of alloy comes under consideration. Zinc around 40 per cent with little tin gives the structure of Muntz metal, which is so characteristic that other alloys of similar appearance are classed in the Muntz metal group. Tobin bronze, manganese bronze and a number of heavy bearing metals come under this classification, and, as far as their zinc content is concerned, they are strictly brasses and not bronzes. Tobin bronze, for example, containing about 59 per cent copper, 38 per cent zinc, 2 per cent tin and a small amount of lead, is in the solid a mixture of the ternary alpha and copper-zinc beta, while all the tin is in the solid solution alpha. A reaction at about 890 deg. C. produces the beta from the alpha and liquid.

From these examples it can be understood that in a true bronze or a true brass the small amounts of zinc or of tin remain in the solid solution alpha, and the presence of the eutectoid on the one hand, and beta on the other, determines the bronze or brass nature of the alloy. These amounts of zinc in bronze or tin in brass do not affect the appearance of the solid alloy—it still remains bronze or brass, but the physical properties change accordingly.

One of the principal effects of zinc on bronze is the greater ease of cold rolling and forging. And its advantages in sea water are well known, especially of Tobin bronze. This alloy has a tensile strength in the neighborhood of 76,000 lb. per sq. in. when rolled, but greater ductility is obtained with a little less zinc. The cast alloy may have a value somewhat less than this, while cold rolling increases it slightly. It must be said that this high tensile strength is obtained at the expense of some of the other desirable properties, ductility for instance. Annealing and quenching play an important part in this connection. If an alloy of, say, 30 per cent zinc is heated to about 700 deg. C. and quenched in water, some beta is retained which would otherwise be absent. Again, a composition in the alpha plus beta range, by the same treatment, is made to consist mostly of beta. If so much tin is present in a bronze that it is ordinarily brittle, quenching from above 600 deg. C. gives copper-tin beta and the result is a workable alloy. The main field of the alloys in the copper corner of the ternary, is strength and salt water uses; those along the tin-zinc side come more strictly in the class of bearing metals or "white metals," particularly the zinc corner. They are harder than the lead-tin-antimony-bearing metals and more adapted to heavy loads.

## The Effect of Phosphorus on Bronze

Phosphorus is added to bronze for either, or both, of two reasons:

1. As a deoxidizer; and, therefore, as it passes into the slag no phosphorus is found in the alloy on analysis.

2. For its beneficial effects; and then it is either, (*a*) all in solid solution, or, (*b*) in the form of the compound $Cu_3P$.

Normally phosphor-bronze contains a large percentage of copper and a very small proportion of phosphorus. Part of the copper-phosphorus diagram is given in Fig. 8. A definite, very hard compound, $Cu_3P$, is obtained with 14.1 per cent phosphorus which with copper forms an eutectic at 700 deg. C. and 8.25 per cent phosphorus. These figures are due to the investigations of Heyn and Bauer. Also copper is capable of holding phosphorus in solid solutions up to 1 per cent on long annealing. Fig. 9 shows the copper corner of the ternary diagram adapted from Hudson and Law's researches but with changes which, while contrary to their theory, seem to be more or less self evident.

Consider an alloy in the area *Cu V X;* alpha, holding a little phosphorus in solution, freezes first until the line *W X* is reached, then beta freezes by the familiar reaction as in bronze until *W* is reached. Here, should liquid still remain, occurs the reaction, alpha plus liquid *W* equals beta plus $Cu_3P$, until the alloy finally becomes solid. Then beta gives place to the eutectoid as usual below 500 deg. C. The final structure then is alpha dentrites surrounded by, and in a ground mass of, an eutectic-like structure of $Cu_3P$ and the eutectoid ($Cu_3Sn$ and alpha). The point *W* (81 per cent copper, 14.2 per cent tin, 4.8 per cent phosphorus, at 620 deg. C.) according to Hudson and Law is the ternary eutectic of the system, but as William Campbell puts it, it could be more truly called a reaction point whereby the liquid with alpha form beta, and the beta in turn forming the eutectic with $Cu_3P$ and causing final solidification. Besides upon further cooling, beta breaks up into the eutectoid and the final alloy (unless quenched) contains no beta. It might be said that the high-phosphorus alloys contain the compound $Cu_3P$ as a pseudo-eutectic mixed with the eutectoid of alpha and $Cu_4Sn$; but with little phosphorus present it is dissolved in the alpha. The line *V W* represents the solidification of alpha and $Cu_3P$ side by side until *W* is reached when the above reaction takes place again. In the area *V W Y*, Cu$_3$P crystallizes out first and along *V W* the changes are the same as explained before. Small amounts of phosphorus seem to lower the solubility of tin in copper from 10 per cent to about 5 per cent, even when annealed.

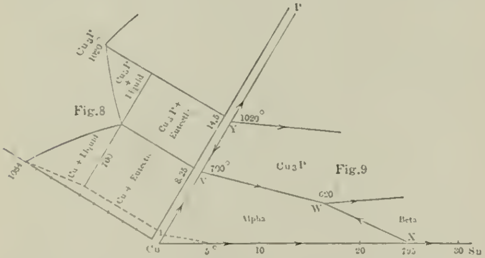
Then if the tin is present much more in amount than this, Cu$_4$Sn is introduced through the eutectoid, which, with the Cu$_3$P, gives two hard substances set in a softer alpha matrix. However, this matrix is harder than the lead-tin anti-friction alloys and therefore the plasticity of the former is less.

In general, the addition of phosphorus to bronze has the effect on the physical properties of greatly increasing the hardness and resistance to wear and for conditions requiring these qualities it surpasses all other alloys.

The other properties of the bronze, *i. e.*, the tensile strength, elastic limit and elongation, are impaired in proportion to the phosphorus added. Consequently, the phosphorus is kept low, relying more on its deoxidizing and cleaning powers to give to phosphor-bronze the good qualities it possesses.

The class of bronze in which both tin and phosphorus are low includes most of the commercial alloys and these show a certain degree of malleability and ductility. The upper limits in composition of these two metals for such properties may be placed at 8 per cent tin and 0.8 per cent phosphorus. Within these limits the phosphorus is held in solution in the solid alpha due to the long annealing which this alloy usually undergoes, and the result is a single homogeneous solid solution. Should this phosphorus limit be too great, so as to admit the possibility of forming Cu$_4$P, the tin hinders the action and further causes the compound to be distributed in finer patches throughout the mass. It is essential that if malleability is desired the hard substances Cu$_4$Sn and Cu$_3$P must be eliminated as far as possible. The commercial alloy frequently contains tin and phosphorus outside the above limits when hardness is not so detrimental to the particular use of the alloy. In fact, it has been found that other metals make up for the excess hardness produced by too much tin and phosphorus and by using such a metal to neutralize their hardening effects, the wide limits could be used to give other qualities and still give as a net result a comparatively soft alloy. Lead is nearly always present for anti-friction and softening purposes when the alloy is used in bearings. The purpose is to get the most suitable mixture of copper and tin to give strength, then harden and deoxidize it with phosphorus, and finally add lead to soften it somewhat and give the necessary anti-friction quality.

The alloy sold as phosphor-bronze has a tensile strength around 30,000 lb. per sq. in.



FIGS. 8 AND 9—TEMPERATURE-COMPOSITION DIAGRAM FOR COPPER-PHOSPHORUS AND PART OF TERNARY

## The Effect of Manganese, Aluminium and Iron on Bronze

In the first place, manganese bronze should be called manganese brass; and, again, a number of alloys sold under this name have no manganese whatever in them. Since manganese bronze is a name standing for strength, brass foundries turn out alloys and sell them under this name in order to market their product. Many of the reputable firms do this, which is admissible, as they have the strength to back their alloys, but it has been found that many manganese-bronzes have their strength only in their names.

In the composition of manganese bronze, aluminium is frequently of a greater percentage than manganese, so the modification could go still further—aluminium brass. Manganese and aluminium "bronze" are so closely related that it is difficult to discuss one without the other. It is true that the real aluminium bronze is still widely used for certain purposes and until the last few years it was a competitor of manganese bronze in the field of usefulness that the latter occupies now. It has been replaced, but in name only, by manganese bronze as the many desirable characters of this bronze are due largely to the aluminium it contains.

Manganese bronze dominates the field of combined strength and non-corrosive alloys. Monel metal is its only competitor—at a higher price. As a bearing metal it finds little application except under very light loads.

High-zinc brass gives unsatisfactory sand castings and therein lies the advantage and object of adding aluminium. Iron gives a high elastic limit to copper and zinc and hence the use of manganese as a carrier of the iron. Metallic iron melted with the alloy gives patches of ferrite which are hard and limit the machining of the metal. When introduced in the form of ferro-manganese this trouble is eliminated. P. M. Parsons was the first to determine the benefits of these added metals and although his patents have since expired, he introduced the alloy in England and later in the United States. His original mixtures have been changed very little.

The manganese bronze in use now has two compositions, one for sand casting and one for rolled sheets and forgings. The following will show about the average analysis and mixture:

| | Sheets and Forgings | | Sand Casts | |
|---|---|---|---|---|
| | Analysis | Founders' Mixture | Analysis | Founder's Mixture |
| Cu.... | 60.1 | 60 lb. (Ingot) | 56.0 | 56 lb. (Ingot) |
| Zn.... | 37.8 | 39 " (Pure Speller) | 41.5 | 43 " (Pure Spelter) |
| Fe.... | 1.3 | 2 " Steel Alloy | 1.2 | 2 " Steel Alloy |
| Sn.... | 0.7 | | 0.7 | |
| Mu.... | 0.1 | | 0.1 | |
| Al.... | .. | .. | 0.5 | ½ " (Ingot) |

Steel alloy: wrought iron 18 lb., ferromanganese (80% Fe, 40% Mn) 4 lb.; tin 10 lb.

The small proportion of manganese and the absence of aluminium in sheets is worthy of notice. When rolling and forging the alloy, better results are obtained with more copper and less zinc than is used in the sand casting mixture. Since both compositions give a Muntz metal structure, more copper will produce more alpha which is better adapted to being worked than beta. Aluminium is the beneficial element in the casting mixture, but since this alloy must be melted first in the proper order and cast into ingot bronze and then remelted for the final casting, it is eliminated in the rolling mixture which then only needs to be melted once.

Iron has an unlimited solubility in manganese and manganese has an unlimited solubility in copper; consequently these extra metals, together with tin and aluminium, are all in solution in the alpha. The copper and zinc percentages give the structure of Muntz metal so a diagram other than Fig. 6 is not necessary to explain the constitution of manganese bronze.

The reported strength values of this alloy vary considerably. The following, however, may be taken to represent averages from the above mixtures:

| | Cast Bars | Cold Rolled |
|---|---|---|
| Tensile strength.......... | 70,000 lb. per sq. in. | 95,000 lb. per sq. in. |
| Elastic limit ............ | 30,000 " " " " | 80,000 " " " " |
| Elongation in 6 in........ | 18 per cent | 12 per cent |

Another type of manganese bronze is used as a resistance alloy. It is white, due to 18 per cent manganese, and contains also about 67 per cent copper, 13 per cent zinc, 1 per cent aluminium and a little silicon. Its tensile strength is around 40,000 lb. per sq. in. for castings but its ductility is low. As to its resistance, it is claimed that 400 ohms per mil foot is a good average, while German silver for comparison, has about 180 ohms.

True aluminium bronze has many advantages that place it in a field of usefulness that cannot be invaded by managanese bronze. The alloy has as its prominent characteristics a low specific gravity and the ability to make sound castings from bronze. But to offset these qualities, the casting shrinks conderably, has low ductility and possible brittleness. It seldom contains more than 11 per cent aluminium. Part of the copper-aluminium equilibrium diagram is given in Fig. 10. It is somewhat similar to the left side of the copper tin curve, alpha holding 7.5 per cent of aluminium in solid solution, and the eutectoid point is at about 11.5 per cent aluminium. The best alloy contains alpha plus beta, obtained by quenching when the aluminium is between 7.5 per cent and 11.5 per cent. On either side of this range of composition, or when the eutectoid is present, the alloy is either weak or brittle. Eleven per cent of aluminium and 90 per cent copper is about the best composition, tests of which give around 80,000 lb. per sq. in. tensile strength. More aluminium causes excess brittleness, while less makes the alloy too weak, as for instance with only 1 per cent aluminium, 25,000 lb. is obtained. By introducing tin the alloy does not seem to be improved; *i. e.*, 88 per cent copper, 6 per cent aluminium and 6 per cent tin gives nearly 65,000 lb. tensile strength, but greater ductility. The gas engine is responsible for the extensive use of an alloy high in aluminium. About the best of this class of alloy is 92 per cent aluminium and 8 per cent copper, to which some founders add a small amount of nickel A tensile strength of 18,000 lb. per sq. in. is near the average value, but its principle advantage lies in its low specific gravity of about 2.8. It withstands repeated vibrations very well, much better than a similar alloy with the copper replaced by zinc, which has more strength.

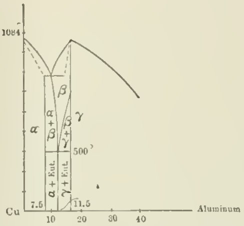


FIG. 10—PART OF COPPER-ALUMINIUM EQUILIBRIUM DIAGRAM

Durango, Colo.

**South Dakota made its record yield of metal in 1912,** in which year the gross value of gold, silver, copper and lead was $8,019,370. In 1913 the yield was valued at $7,424,333 from 30 producing mines, including 10 placers. There was 1,895,445 tons of ore treated in the state, yielding an average recovery per ton of $3.81 in gold and $0.052 in silver. The Homestake mines and mills produced and treated 1,540,961 tons of ore, yielding bullion valued at $6,186,652, or $4.01 per ton.

# Notes and Observations on Ore-Treatment at Cobalt, Ontario, Canada

BY H. C. PARMELEE

Ten years have elapsed since Cobalt made its first contribution to the silver production of the world. Within that period the shipment of silver ores and concentrates has increased in value from $136,217 in 1904 to $16,555,001 in 1913.[1] Shipment of bullion produced in the district increased from a value of $501,815 in 1910 to $5,895,449 in 1913. In the latter year Cobalt was credited with 14 per cent of the world's production of silver.

Mining at Cobalt always has been characterized by many spectacular features which have become a matter of common knowledge. The richness of the ore, the large masses of native silver, the deposits of cobalt and nickel minerals, and the development of an immense mining industry in a region supposed to be valuable only for agriculture and lumbering—these features have characterized Cobalt. Mining has indeed been unique, but no less striking have been the recent metallurgical advances, resulting in the accomplishment of things considered improbable, if not impossible. Nor is the end yet in sight, for there are indications that Cobalt is entering on a period of progress in metallurgy that will develop further novel processes and methods. Large problems still exist and good men are attacking them.

### Present Situation and Future Prospects

Leaving out of consideration for the present the specific technical problems at Cobalt, the general economic situation is about this: In the early years of its history the district produced principally high-grade silver ore.

Other valuable minerals, chiefly of cobalt and nickel, existed in the ore, but their value was not comparable to that of the silver, and they received but littel consideration, metallurgically speaking. Silver was the metal of chief value, and the ores were shipped and smelted for its recovery. Cobalt, nickel and arsenic were by-products of little economic value to the producer.

Low-grade ores also were developed, and these were enriched locally by ordinary methods of water concentration. The concentrates, too, were shipped from the district and smelted at other places in Canada and the United States. With the gradual and inevitable exhaustion of the high-grade ores, there was an increase in production and concentration of low-grade material. This tendency has been marked in the last few years: in 1912 the concentrating mills treated 390,473 tons of crude ore, and in 1913 they handled 531,548 tons. The prospect for the current year is that a still greater tonnage of low-grade ore will be enriched by concentration.

One of the most clearly defined elements of the situation, therefore, is that ore-dressing is a factor of increasing importance in the district. Lower grades of ore will be mined, old mine dumps will be treated, and every effort made to conserve the diminishing resources just as far as mechanical methods can be applied.

This means an increased production of the table concentrates, coincident with a decreased output of high-grade ore, and has an important bearing on the future of metallurgy in the district, as will be pointed out later.

---

[1] Statistical data are quoted from the 1914 report of A. A. Cole, mining engineer to the Temiskaming & Northern Ontario Ry. Commission. This report is published annually and distributed by A. A. Cole, Cobalt, Ontario, Canada.

### Local Production of Bullion and By-Products

Another feature of the metallurgical situation, which has been recognized by the progressive companies in the district, is the desirability of producing bullion at the mines instead of shipping ores and concentrates to smelters. The local output of a finished product, salable to mints or other consumers of silver, and the recovery of valuable by-products such as cobalt, nickel and arsenic, would be preferable to the shipment of raw material requiring further treatment, providing economic methods could be devised that would gain for the producer the profit which it may be assumed the smelter is making. Judging from the research now under way, it may be safely predicted that the production of silver bullion and by-products will increase, and shipments of raw material decrease considerably in the next few years. The general tendency toward the increased local treatment of ores by all methods—concentration, amalgamation and cyanidation—is shown by the following figures: for 1912, 455,517 tons; for 1913, 664,845 tons.

The reduction of ore to bullion and the recovery of some by-products has been an accomplished fact at Cobalt for several years past, but has been confined mainly to the treatment of high-grade ore and tailings from concentration. By far the greater proportion of the tonnage mined is concentrated, but the local reduction of table concentrates has not been as extensively practiced as it will be.

A scheme of amalgamation in strong cyanide solution is used for high-grade ore, while low-grade ore and tailings from concentration are treated by cyanidation only. The Nipissing company is successfully cyaniding ores similar in grade and character to those ordinarily concentrated at other mills; the Dominion Reduction Company is cyaniding concentrates and tailings separately; the Buffalo company is reducing jig and table concentrates with high-grade ore, and both the Buffalo and O'Brien are cyaniding slime tailings from concentrates. Details of these methods will be referred to later. The following tabulation shows the reduction methods used and materials treated.

| Company | By amalgamation and cyanidation | By cyanidation |
|---|---|---|
| Nipissing | High-grade ore and jig concentrates | Low-grade ore. |
| Dominion Reduction | Table concentrates | Slime tailings from concentration. |
| Buffalo | High-grade ore, jig and table concentrates | Slime tailing from concentration. |
| OBrien | | Slime tailings from concentration. |

### A Complex-Ore Problem

The recovery of the valuable metals from the ores and concentrates of the Cobalt district presents a neat metallurgical problem, particularly with reference to table concentrates. Here we have truly a "complex-ore problem," although different in kind from what is usually understood by that term in the western United States. In order to appreciate the condition at Cobalt, consider the list of the principal minerals contained in the ores: native silver, sulphides of silver and nickel, arsenides of nickel and cobalt, arsenate of cobalt, sulpharsenides of iron and cobalt, antimonide of silver, sulphantimonite of silver, and some others. These minerals represent at least four metals of economic importance—silver, cobalt, nickel and arsenic—the recovery of which offers an opporunity for research and operative skill.

The reduction of table concentrates presents a different problem to that offered by high-grade ore. Comparatively little difficulty is experienced with the latter, as the silver is mainly in the native state and yields almost a complete recovery by amalgamation in cyanide solution. Table concentrates, however, differ in containing a large proportion of the complex silver minerals and a smaller proportion of native silver. This mineral content is the main factor in the problem of reducing table concentrates and recovering therefrom the several metals of economic value.

Essentially two lines of attack are being made on this problem—by amalgamation and by cyanidation. Each is marked by a high consumption of the chemical employed and involves some scheme for its recovery.

Amalgamation will yield silver bullion and a residue containing principally cobalt, nickel and arsenic. There will be a comparatively heavy chemical consumption of mercury, due to the formation of mercury sulphide which remains with the residue. This necessitates a treatment of the residue for recovery of mercury. Such a process is in use at the Buffalo mill, and as soon as operating data are obtained we expect to be able to present details of the process and the metallurgical results.

Cyanidation of table concentrates, on the other hand, is being investigated by the Nipissing company. No details of results have been made public, but it can be surmised that a high chemical consumption of cyanide will ensue, and that some method for its regeneration and for the recovery of metals, other than silver, taken into solution, will be a part of the process. This research should add greatly to our knowledge of cyanide chemistry. It is expected that a process will be developed whereby high-grade ore concentrates can be treated by cyanidation only, eliminating amalgamation as now practiced by this company.

The outcome of these two different lines of research will be awaited with interest, for their success means much to the Cobalt district in the local production of bullion. The ultimate superiority of one method over the other must be determined by the metallurgical and economic results and the mechanical requirements, as shown in practical operation.

Chlorination has been proposed for the treatment of these ores, and some experimental work has been done by interested parties. Mr. John L. Malm, of Denver, made tests several years ago according to a method[2] which he has advocated for complex base-metal ores of the western United States; and in our last issue we recorded the details of a process[3] patented by Mr. Oscar Dyckerhoff, of Karlsruhe, Germany, specially applicable to Cobalt ores.

### Retreatment of Sand Tailings from Concentration

The sand tailing dumps at some of the concentrators in Cobalt represent an asset worthy of conversion into money. The successful treatment of this material constitutes another metallurgical problem which is being investigated by several companies, and it is likely that within the next few years a large tonnage of this material will be treated by cyanidation.

The silver content of sand tailing will range from 4 to 8 oz. per ton. In the opinion of engineers thoroughly familiar with conditions and competent to judge, there is more 6 to 8 oz. tailing than is generally admitted. This is particularly true of earlier practice. Exceptions exist as in all such cases, and there are some sand dumps containing only 3 to 4 oz. silver per ton.

Under present conditions it is unlikely that any attempt will be made to retreat these lower-grade dumps, but enough work has been done on others to indicate the advisability of erecting the necessary grinding and cyaniding plants for their treatment. Dump sampling is not difficult, particularly where the tailings have been stacked and not run into the lakes. The piles are quite uniform in value, and accurate estimates can be made of their metal content.

---

[2] This journal, Feb., 1914, p. 128.
[3] This journal, June, 1914, p. 412.

Generally speaking these sand tailings, and very low-grade ores too, require fine grinding for the liberation of metal and mineral from the enclosing gangue. For this reason it is unlikely that further concentration would be an effective treatment. Screen analyses of sand dumps show a marked concentration of silver in the finest portion, say 200-mesh and finer, while the grades from 20 to 150-mesh, inclusive, will assay about the same as the whole sample. The following tabulation illustrates this condition, the figures representing a fair average of sand tailing containing about 6.5 oz. silver per ton.

| Mesh | Per Cent by Weight | Oz. Silver per Ton |
|---|---|---|
| + 20 | 30 | 6.5 |
| + 40 | 35 | 6.2 |
| + 60 | 21 | 6.2 |
| + 80 | 7 | 5.8 |
| + 100 | 3 | 5.7 |
| + 150 | 2 | 6.3 |
| + 200 | 1 | 8.5 |
| — 200 | 1 | 28.6 |

Similar results, though with less striking concentration of metal in the finest portion, are obtainable from 3 and 4 oz. sand tailings.

The cyanidation of this material seems to offer no serious obstacles, when ground so that about 90 per cent. of the solids will pass a 200-mesh screen. By grinding in a tube mill in cyanide solution, and agitating the thickened pulp, an extraction of 90 per cent. is possible. A system of continuous counter-current decantation following agitation would complete a very simple and effective plant. The finely ground material is sandy and settles readily, so that from 5 to 7 sq. ft. of settling area per ton of dry slime is quite sufficient. The cost of cyanide would be from fifty to sixty cents per ton, and the total cost of treatment probably not more than $1.75. Thus on material of $3 to $3.50 gross value, a fair profit could be realized, but 4-oz. tailings would not much more than pay for treatment.

Some interest is being taken also in the possibility of applying flotation to reground sand tailings, but only a few tests have been made. The point to be determined in this connection is whether the use of an intermediate concentrating process, followed by cyanidation or amalgamation of the concentrates, would yield a higher economic return than could be obtained by direct cyanidation as just outlined. The apparent advantage of flotation would be the greatly reduced volume of material to be treated in the final process, due to the rejection of the bulk of the gangue in the flotation process. This is a line of investigation that may be pushed further, as there are several types of flotation processes, one of which might be found specially applicable.

### Cyanidation of Slime Tailings from Concentration

At two mills in the district, slime tailings from concentration are being cyanided. According to the report of Mr. A. A. Cole, previously mentioned, the Buffalo company in 1913 cyanided 11,744 tons of slime and produced 110,505 oz. silver; the O'Brien mill treated 39,663 tons of slime, producing therefrom 228,544 oz. silver. These facts suggest that the slime tailings now being wasted from concentrators are more valuable, ton for ton, than the sand, and that a recoverable asset is being neglected. Not only is it being neglected, but in some cases it is being put beyond the possibility of ultimate recovery by being discharged into lakes instead of being impounded.

There are several reasons why this preventable waste is to be deplored. In the first place a great deal of energy has been expended in grinding this slime, so that most of it is in a condition suitable for cyanidation, and would require but little more grinding. Again comparatively simple means are at hand for applying the cyanide process, and the additional cost of machinery, chemicals and labor would not be prohibitive in view of the possible recovery. If it is regarded as feasible to regrind and cyanide a 6 to 8 oz. sand tailing, it would seem possible to cyanide slime tailing of the same value which is already ground much finer, and requires practically only agitation for solution of the silver. Finally, this further treatment of slime offers a simple expedient for adding to the recovery effected by the concentrator, and should appeal to progressive metallurgists. Perhaps concentration by flotation might be applied to this material, and in that event the pulp would be ready for treatment after a preliminary thickening. Economically, however, it is likely that cyanidation, with its production of bullion, would be preferable to flotation and the recovery of concentrates requiring further reduction.

At the O'Brien mill the ore is first jigged in water and the jig tailings are then crushed in stamps in cyanide solution. Hardinge and tube mills are used as regrinders, and Deister tables make a further concentration of the reground pulp. Slime is finally separated by Dorr classifiers, thickened, agitated and filtered. The cyanide department at the Buffalo mill is an adjunct to the concentrator, and the scheme of treatment includes well known methods of thickening, agitating, filtering and precipitating.

Other companies in the district are now considering cyanidation as a logical extension of their work in concentration. Until methods are adopted which eliminate concentration altogether, this idea is an excellent one and worthy of wider use. The fullest credit is not reflected on the metallurgist as long as an economically recoverable asset is being wasted. In this problem, of course, are involved the life of the mine, the daily mill tonnage and the cost of additional plant.

## The Story of Mining and Metallurgy

At the fiftieth anniversary of the School of Mines of Columbia University, on May 29, 1914, Mr. T. A. Rickard, as the official representative of the Royal School of Mines, London, made a brilliant address on the calling of the mining engineer and metallurgist.

Mr. Rickard spoke as follows:

"It is a common saying that agriculture and mining are the two basic industries. When man rose above the brutish individualism of his primordial state and began to develop the social instinct, he turned to the soil, in order to win food for his family. He paused in his migration, the soil held him; it gave root to his rudimentary community; it gave him the chance to enlarge his energies. His tracks became highways; his rivers, avenues of trade; and as his traffic expanded, so his imagination widened, until, out of the crudities of communal development grew the complexities of civilization.

"But the nomadic habit lingered; the spirit of the hunter survived in man; a wanderer and a wonderer he stood beneath the starry dome of the forest arch not knowing whether he were the guest or a captive in the domain of Nature. The hills beckoned; the seas called; the more venturesome left the tents of the tribe in search of material wherewith to fashion their implements. They sought iron for weapons, copper for tools, gold for ornament, and found them in various guise in the earth under their feet. They became miners. To those who delved successfully came power. Throughout the ages the more energetic and adventurous broke from the plough and forsook the cattle in order to explore and to exploit. They brought the metals from which the artificers fashioned engines of power and machines of intelligence. They won the materials for a social structure that, based on stone and built in iron and copper, soared in many-storied tracery of steel to towers radiant with light and vibrant to the sky—towers so far above the common ground that man almost forgot his lowly origin and claimed kinship with the stars.

"The story of mineral exploration and racial migration is peculiarly the heritage of our people, the Anglo-Celts. It is the *motif* that runs through the drama of English and American history, more particularly during the last hundred years. Even in its barest outlines it serves to suggest that the miner is the pioneer of industry and the herald of empire.

"The first social organizations around the shores of the Mediterranean sent their prospectors to the hinterlands of Europe, Asia, and Africa. The gold of Ophir, the copper of Sinai, the silver of Laurium were part of the web and woof of those early civilizations. The mines of Iberia gave Hannibal the sinews of war against Rome, and the gold of Davia strengthened the resources of Rome under Trajan. But the greatest adventure was that of the Phoenicians who passed through the Pillars of Hercules into the western ocean in order to reach the far Cassitorides, the tin islands that in turn were to produce those Cornishmen to whom the world is one big mine. After Carthage and Rome, in turn, had been overthrown, the mining industries of the known world were disorganized. Desultory operations persisted in Hungary, Spain, and Saxony, but the Middle Ages to the miner were as dark below ground as above. Even the discovery of America, which marked the beginning of a new world movement, was not connected with a real advance in mineral exploitation, although associated with the winning of gold and silver. It is true, the wave of Spanish conquest broke over the American continent, penetrating the treasure-vaults of Mexico and Peru. But the Spaniard devastated, he did not develop. He gathered the harvest that the patient Indian has sown by the laborious toil of centuries. Cortez and Pizarro were filibusters, not explorers; they were pirates, not miners. The *conquistaderes* were no pioneers of industry; behind them arose the smoke of ruin and the dust of destruction. Even the great sea-captains of Elizabeth were but the sequel to an epoch of spoliation. After them, and in their wake, across the sea, came the men who from Cornwall and Devon, from Saxony and the Harz, brought the technique of mining to the new world, applying it peacefully to the mineral development of Mexico, Peru, and Chile, all along the regions previously ravaged by European freebooters.

"But the great era of mineral exploration came with the discovery of gold in Australia and California. It was the prelude to a worldwide migration, an enormous expansion of trade, a tremendous advance in the arts of life, and the spread of industry to the waste places of the earth.

"The colour of energy began to tint the blank spaces on the map. The western half of the North American continent, all of Australia, the southern half of Africa, the northern half of Asia, were invaded, penetrated, and explored by those in search of gold, of other metals, and as each successive mineral discovery was made by the miner he called upon his fellows to come and take a hand in the good work. He was the scout far ahead of an army of development. Trade follows the flag, it is true, but the flag follows the pick."

Mr. Rickard then told of the finding of gold in California by James W. Marshall on January 24, 1848, and of the sudden rush of the gold seekers to the Pacific Coast which is so well known in the history of California and which resulted in the production of $81,294,700 in gold in 1851, giving details of the subsequent history of the industry. Among those who were first in those fields was E. H. Hargraves, an Australian, who was led by the analogy of geologic conditions to those in his own country to suspect the occurrence of gold there, and he returned to his home in New South Wales, where on April 3, 1851, he announced the discovery of gold in Australia. The rush to those gold fields was great and in 1853 the gold production there was $54,882,000. The first diamond was found in South Africa, he said, in March, 1869. The history of the de Beers and Kimberly mines, the discoveries in other regions of the Rand and in the West African gold fields, the story of the Yukon and Klondyke were next told. After speaking of the great work of prospectors in the development of the countries they visited, Mr. Rickard concluded by saying:

"After the prospector has come the mining engineer. The scout has gone in advance of the captain of industry. Those of you that have crossed the range in winter know how the loader breaks the trail by leaving footprints into which his followers tread, step by step, greatly to the safety and ease of their travel. That is what the mineral explorer has done for the mining engineer. That is what the mining engineer has done for those behind him. Some of you have been prospectors as well as engineers.

" 'Have you known the great white silence, not a snow-gemmed twig aquiver?
Have you broken trail on snowshoes; mushed your huskies up the river?
Have you marked the map's void spaces,
Felt the savage strength of brute in every thew?'

"Again I ask you to recall how you threaded the pathless forest on your way to examine a new mineral discovery. On the trees at intervals you have seen that the bark was chipped. The trail has been 'blazed' by the prospector, making it easy for you and others to follow. That is what the miner has done in a larger way for civilization. He has done it with geographical exuberance and equatorial amplitude. From 'the stark and sullen solitudes that sentinel the Pole' to the 'steaming stillness of the orchid-scented glade' in the Tropics, he has left his mark. You know that. No need for the prospector to complain to you, like Kipling's explorer:

" 'Well, I know who'll take the credit: all the clever chaps that followed—
Came a dozen men together—never knew my desert fears;
Tracked me by the camps I'd quitted, used the water holes I'd hollowed.
They'll go back and do the talking. They'll be called the Pioneers!'

"No; not by the men of the Columbia School of Mines, who have shared the prospectors' camp-fire, his blankets, his flapjacks, and his beans. You will give credit to whom it belongs. To the man with the faith of a child and the heart of a viking, to the man who has tramped and toiled until he heard "the mile-wide mutterings of unimagined rivers and beyond the nameless timber saw illimitable plains"; to the miner who has crossed the last range of all and lies in the only prospect-hole he could not dig; to the man who was the herald of empire and the pioneer of industry; to him who 'blazed the trail.' "

# Is There a Complex-Ore Problem?

## A Symposium on the Economics and Metallurgy of Mixed Base-Metal Sulphide Ores, Showing Present Status and Future Prospects of This Branch of Ore-Treatment

In our May and June issues we presented a number of replies received in answer to a set of questions propounded to leading metallurgists on the general subject of complex ores. The interest manifested in this inquiry has been all that could be expected, and indicates how widespread is the problem that is being attacked by many different methods and from different angles. We present below two additional replies that have been received, together with an editorial summary of the subject. For convenience in following the trend of the replies, the questions are here reproduced.

1. Is there a "complex-ore problem," and what, in your opinion, constitutes a "complex" ore?
2. Would such ores be amenable to present methods in the hands of skilled operators, or is there a need for new methods of treatment?
3. Do you believe there are many mines now idle which could produce a considerable tonnage of such ore if suitable methods of treatment were known?
4. What element or quality of such ores makes them refractory to present processes?
5. What methods or processes do you regard as probable solutions of the problem (mechanical, hydrometallurgical, electrometallurgical)?
6. To what extent would microscopical examination of such ores be of material assistance in suggesting proper methods of treatment?

**F. L. Clerc.**—The symposium to which we are invited for the discussion of the complex-ore problem has proved a social success. Let us all raise our glasses, whether they be eye-glasses, laboratory beakers, microscopes or telescopic lenses, to pledge ourselves to contribute to its solution; and in honor of the sentiment of cordial cooperation, drain the new life typified by the generous juice of the grape. My rôle must be mainly to second the motion, or endorse the opinion, of the last speaker. The subject has been covered so fully that any amendment I will suggest appears to me to be in the way of more fully expressing opinions already set forth. It is always of interest to know just how far such support and endorsement goes. This can be shown by a categorical answer to the questions submitted.

1.—Yes, there is a complex-ore problem, a general one: The maximum utilization of the valuable constituents of mixed mineral substances, and the discovery of uses for the other constituents. A complex ore is one in which the mineral or minerals containing one valuable constituent are intimately entangled with minerals containing other valuable or, at present, worthless constituents.

2.—All known mineral substances and compounds can be separated by laboratory methods. Metallurgical operations are modifications and extensions of laboratory manipulations. The question of profit involved may be answered Yes, if the skilled operators can live in the meantime.

3.—The lean-ore problem presents itself at every working mine, as attested by the mine dumps and piles of tailings and polluted streams. If these complex mixtures could be utilized, the tonnage from mines now working would be greatly increased. These mines could be opened and worked to better advantage, and the danger of losing the bonanzas by too contracted workings would be lessened. Doubtless there are many abandoned mines and discovered mineral deposits which can be profitably worked if the valuable constituents of the leaner complex ores can be made useful.

4.—The element which makes complex ores refractory to present processes is that one of least value commercially; that is, after deducting the cost of treatment. The quality which contributes to refractoriness is the intimate entanglement of minerals which require different treatment for the extraction of the valuable metals they contain.

5.—All of the methods or processes mentioned have their application to special cases of the general problem. They are being constantly improved in practice. All mechanical separations of ore containing one or more valuable constituents are stages of metallurgical treatment; even selective mining, crushing, hand-sorting and any method of separation or concentration. Transportation from mine to mill or smelter is included in the handling of ores, and a saving in any of these items renders increased amounts of complex ores amenable to existing processes for utilizing valuable constituents. My own experience leads me to believe that there is an opportunity for the wider use of pyrometallurgical concentration—either with carbonaceous smelting or sintering, pyritic smelting or electrothermic smelting—and in the last few years I have advocated the use of such processes for the preliminary treatment of the zinc carbonates and silicates of Leadville, and other base-metal ores.[1]

All of those who have been present at this symposium appear to be in harmony in the opinion that whether any broken mass of rock is or is not an ore, depends on where it is, who owns it, and on the current market price of its valuable constituents, as well as on the skill and knowledge of the metallurgists who handle it. Among the environments necessary for the survival of metallurgical enterprises may be mentioned sufficient capital, a favorable location and good administrative and executive management. Any enterprise may fail if any one of these conditions is lacking.

6.—A hand magnifying glass is generally sufficient to determine how far mechanical processes will apply, or, if not, a small-scale test can be made in a metallurgical laboratory. In hydrometallurgical processes it is often of importance to know just how the various constituents are associated in the ore. In this case microscopic examination is very useful to supplement chemical analysis. But such examinations and small-scale tests need only be made once for a given ore: that is, until there is a change in the material treated. Yet I have known of cases where silicate of copper, existing in very small quantities in a silicious gangue, has been treated under the supposition that the copper existed as carbonate; also of silicates of zinc which were supposed to be carbonates; and of gold in sulphides which was supposed to be free. In short, no available means should be neglected to learn all we can about the ore to be treated before we reach or pronounce a judgment. From the nature of the case, such microscopic examinations of small-scale tests can best be made by specialists who have exceptional training and laboratory equipment.

Estes Park, Colo.

* * *

**L. D. Godshall.**—1.—There is a complex ore problem. In my opinion a complex ore is any ore which contains a valuable metal or metals difficult to save. Such complex ores may include:

---

[1] The Utilization of the Zinc Carbonates and Silicates of Leadville, Colo., *Proceedings* of the Colorado Scientific Society, Vol. X, pp. 85-98. A Zinc Retort with a Copper Bottom, this journal, Aug., 1912, p. 463. Igneous Concentration of Metallic Values from Mixed Sulphides, this journal, April and May, 1914, pp. 250 and 307.

(*a*) An intimate mixture of base-metal sulphides containing lead, zinc, iron and sometimes copper, with or without gold and silver, a small or large amount of gangue material, and presenting more or less difficulty in the concentration or separation of the various minerals by reason of crystalline texture or insufficient variation in specific gravity of the minerals to be separated.

(*b*) A single metal like gold or silver, in a gangue too silicious or expensive for direct smelting, but presenting serious difficulties in concentration, amalgamation or cyanidation, by reason of part or all of the metal being contained in a mineral too minutely disseminated, or easily slimed in crushing, or by having present in the ore other constituents like manganese, tellurium, etc., which may interfere with the process to be used.

2.—Many of these so-called complex ores are amenable to present methods in the hands of skilled operators. There is always a need for new methods of treatment as well as a need for improvements in present methods. The need for new methods can be illustrated by the present work at Chuquicamata; the need or value of constant improvement in present methods, by the slime treatment at Anaconda.

3.—Large mines or extensive deposits of any ore are scarce, and inasmuch as large ore-bodies present great commercial possibilities if economically treated, much more effort has been expended trying to solve the problem of correct treatment for such ores than for small and relatively unimportant bodies of ore. There are many mines capable of producing from 10 to 50 tons of ore per day if suitable methods of treatment now known were properly used.

4.—The nature of ores which are commonly termed refractory should, I think, be considered as apparent and real.

Many ores commonly termed "refractory" are so only because of inefficiency in the treatment applied to them, due to ignorance and bad management.

With some ores the refractory nature is real, and evidently not to be overcome by means of present known methods. Such instances would represent the extremes as described in the above definition of a "complex ore."

5.—In the comparatively few cases representing the extreme refractory ores, it seems evident that we must look for an improvement in our present methods of separation, mechanical or chemical, by fire or electricity, or else discover methods or processes not yet existent.

For the great majority of so-called refractory ores found all over the West in mines capable of producing, as above stated, from 10 to 15 tons per day, we must look for greater efficiency with our well known processes of today. To obtain this greater efficiency the small operator must be educated to seek the assistance of experienced metallurgists and engineers in order to get *started* properly. The large company or the large property will have talent and capital at hand to solve almost any difficulty capable of being solved, and one or half a dozen failures will not prevent the big problem from final solution. With the small operator the case is very different. In the first place he has not the capital necessary to retain, for any great length of time, the high class engineer or metallurgist, and one mistake often puts him and his company out of commission. It is also a well known fact that the small operator who can least afford to try new-fangled methods is in very many cases the very first to do so. There are numerous monuments in every camp in the West illustrating this sad feature.

The difficulty in successfully handling a small output is very great, and recognized to such an extent that large companies will not consider small properties on account of the difficulty in keeping operating expenses down. It is possible to build, and I believe the near future will see, small plants as complete and almost as economical as our large ones; and when so built are equipped with the machinery and process *adapted to the ore*, and operated with the same conscientious care and detail as the large plant, we will consider many of our so-called complex ores anything but complex.

6.—I consider microscopical examination simply an aid to the visual examination of the ore. In concentration or separation it is necessary, of course, to have the crystal of the mineral we aim to save or separate free from the gangue or other mineral. If the microscope shows crystals of a certain size, we can crush the ore to that size, or if the crystals are so small that the freeing of same would require the practical sliming of the ore, we know before we make the attempt that concentration or mechanical separation will not be successful.

Tecopa, Cal.

* * *

### Editorial Summary

Impressions sometimes become settled convictions without sufficient warrant or evidence, and occasionally it is worth while to stop and make inquiry into a condition to see to what extent current opinion represents the truth. For some years past it has been a simple expedient to attribute depression in the western mining industry to "complex" ores for which no suitable method of treatment was known; at least this has been assigned as one of the contributing causes. "Complex ore" became the ready excuse for idle mines, lack of ore and unsuccessful mills, as well as the convenient explanation for a multitude of metallurgical sins.

We are not even intimating that really complex ores have not been discovered, or that they do not still present problems in metallurgy; but it seemed to us quite likely that some phases of the situation had been overstated or misrepresented through ignorance, while the true and more hopeful aspect of the case had not been expressed. In other words, it seemed likely that some of the general and popular impressions regarding the complex-ore problem had been created by radical spirits who either were not aware of, or did not appreciate, the constructive work of those who viewed the situation more conservatively.

Believing that a widespread public expression of opinion on the subject from many different points of view would be helpful and valuable, we sought the cooperation of prominent metallurgists and have presented their views. That there is striking unanimity in their attitude on some points, and but little diversity of opinion throughout, suggests the belief that we have secured a fair composite view of the whole situation. In geographical distribution the replies cover the whole country; in personnel of contributors they represent diversity of viewpoints and interests.

1.—All are agreed that there is a complex-ore problem, having reference to the economic treatment of mixed base-metal sulphides containing gold and silver. Several contributors emphasize the fact that there are many such problems instead of one; that neither ores nor processes are twice alike, and that each must be considered as a separate problem. Mr. Thomson considers the problem less serious and not as general as is commonly supposed, having in mind no doubt the exaggerated ideas as to the available quantity of refractory ores. In this he is supported by Mr. Swart who regards the problem as not wholly metallurgical, but closely related to the economics of mining—"the location, size and character of the ore-bodies." This takes the burden partly off the metallurgist who, in Mr. Swart's opinion, will successfully treat the ore "if there is enough of it." Mr. Bleecker voices a similar sentiment, and at the same time casts reflections on the alleged abundance of complex ores, when he says that "if the mine is not exhausted by the loss of this quantity of ore" (necessary to make a test) there is hope of solving the problem. Mr. Clevenger, on the other hand, viewing broadly the economics of metallurgy, believes that the problem always is with us "so long as the percentage of extraction is below 100 and the working costs are greater than 0."

As to what constitutes a complex ore there is also a general agreement, although it is apparent that a wide variety of ores can be included in the term. Generally speaking they contain sulphides of lead, zinc, iron or copper, with or without gold and silver, zinc being regarded as a characteristic constituent. Prof. George and others cite a wide variety of complex ores.

From the ore-dressing point of view Mr. Guess and Mr. Collins regard as complex, an ore containing several metals which have to be separated, and which are difficult to separate into marketable products; and which, we might add with Prof. Richards, "would have greatly increased value if separated." This implies, however, the *possibility* of such separation, even though it may not be done as satisfactorily or profitably as might be wished.

An extension of this classification covers similar ores of such physical characteristics as to *preclude the possibility of any separation of minerals* by ore-dressing devices. Hence, Mr. Bleecker and Mr. Johnson apparently regard ores as complex when they "cannot be treated by standard mechanical devices," or do not "admit of separation by mechanical methods." Mr. Bell cites an excellent example of this kind of complex ore.

This distinction between complex ores according to their amenability to mechanical methods of separation is more relative than exact, because as Mr. Croasdale points out, many of the ores now profitably treated by modern mechanical methods are subject to great losses; and sometimes the penalties on undesirable elements become prohibitive, as suggested by Mr. Ionides. The mere fact that ore-dressing methods are being used on some ores does not greatly affect their classification as complex; so that whether an ore can or cannot be treated mechanically, the problem remains of conserving resources, on the one hand, and making new ores available, on the other.

The smelter's point of view is reflected by Messrs. Austin and Traphagen. The former "might limit the definition to cover mixtures, in the treatment of which the extraction of one metal interferes with the recovery of another," and cites an ore containing zinc blende in addition to sulphides of lead and copper. Dr. Traphagen mentions the same fact and says that "our metallurgical processes save but a few metals and sacrifice others of value." Mr. Clevenger points out the flexibility of the smelting process and its ability to treat a wide variety of ores, but he recognizes the inevitable loss of some constituents, notably zinc.

2.—In the discussion on the skilful use of present methods (ore-dressing and smelting) versus the need of new processes, we find a tendency to support the former while acknowledging the latter. Here we come squarely up against the classification of complex ores into those which can and cannot be treated by mechanical processes.

Mr. Swart is quite certain that "by far the greater proportion of (complex) ore can be successfully (profitably) handled by mechanical methods," in which opinion Mr. Godbe concurs. Mr. Collins regards these ores as "amenable to (imperfect) separation by known methods or combination of methods." Prof. Richards thinks that "some of these ores would yield to present processes skilfully applied," and Mr. Thomson states that "such ores are in part amenable to treatment by present processes when properly conducted." These and other contributors recognize the need for more skilful operation, and the possibility of thereby improving results in ore-dressing; but an implied apology is made for the inherent limitations of the methods themselves.

Mr. Skinner, however, comes out squarely with a defense of ore-dressing methods and a strong criticism of the inefficient way in which they are used at many mills. "It is not a fact that poor methods make the losses high, but that the handling of ore-dressing methods is deplorable. * * * The poor quality of mill operation is no doubt responsible for the notion that there is a complex-ore problem." His comments on the operation of average mills are worthy of consideration. He recognizes, of course, that "it would be very foolish to say that some new procedure would not prove, in some cases, more desirable than the known methods," but it is his opinion that "with the possible exception of electric zinc smelting," and under conditions known to him, "complex ores should be treated by simple ore-dressing followed by the old procedures, as against any new chemical or other sort of scheme outlined to date."

On the other hand, and relating particularly to those ores which all agree are not amenable to mechanical processes, we find a demand for new methods. As Mr. Canby aptly says, "the amenability of these ores to present processes is not a question of operating skill." Dr. Traphagen acknowledges the possibility of improving present practice by more skilful operation, but does not see "as much room for progress in present methods, particularly mechanical processes, as in the development of new methods." Mr. Ionides calls attention to the combined losses in ore-dressing and smelting, and Mr. Croasdale suggests that "it is scarcely conceivable that the cost of treatment in a more direct and refined metallurgical process, whatever it may be, will exceed the cost plus the losses sustained by mechanical concentration and smelting."

3.—Whether there are many mines now idle which could produce a considerable tonnage of complex ore if suitable methods of treatment were known, is, we believe, one of the points on which popular opinion has been in error. The consensus of opinion of our contributors is that there are not many such mines. In other words, complete idleness in the mining of complex ores is likely to be due not so much to the real lack of treatment methods as to other economic causes. Mr. Swart sees the real problem in "small, scattered and dissimilar" ore-bodies, and attributes idleness to "such conditions as inaccessibility, heavy snow, poor transportation, high freight rates, high fuel, distance from market, lack of water, poor financing, bad management, ignorance, and improper mining and milling methods." This is an array of economic conditions outside the control of the metallurgist, and they suggest that the lack of a process is not the main reason for idleness of complex-ore mines.

As to the contrary opinion gained by Mr. Johnson from letters received as the result of "a two-month's campaign which had for its object the gaining of information as to the need of a process" for treating these ores, we question the value of such information. The average mine owner is a wonderful optimist regarding his property, and frequently obsessed with the idea that all his "mine" needs is a "process." Only those who have had experience can sympathize with Mr. Clevenger when he says that "it is no unusual thing for tremendous deposits * * * to shrink into nothing upon careful examination." Probably others have had the experience of Mr. Thomson who has examined many such alleged mines and found that "quantity of quality of ore was lacking in every case."

All this, however, does not preclude a genuine need for metallurgical improvement, even at mills now operating; for the method treatment, while profitable, may be yielding poor economic results. It is recognized also that there are some mines, although they are few, at which production is deferred awaiting metallurgical development.

4.—The object of our fourth query was to see whether any particular quality—physical, chemical or both—could be considered as characterizing complex ores. The replies are fairly in agreement, and a number of good points are brought out. From the ore-dressing point of view the following qualities may cause ore to be classified as complex: Intimate physical association of the constituent minerals; fineness of crystallization and friability of minerals; narrow margin between the specific gravities of sulphide constituents; similarity of specific gravity of mineral and gangue; chemical combination of different metals in a single mineral; similar action of minerals in flotation; and equivalent electrical and magnetic properties of minerals.

The economic phase is suggested by Mr. Collins, who says "it is mainly a matter of costs and market values"; and by Mr. Bleecker who observes that "an ore is not necessarily worth treating because the total values foot up to ten or twenty dollars per ton."

On the chemical side, those who seek to lay the cause of complexity at the door of a single constituent element are unanimous in selecting zinc as the offender. This metal has to bear the brunt of losses and penalties, and its recovery is one of the fundamental features of newly proposed processes. Prof. Richards speaks of zinc as "the worst stumbling block in the metallurgy of complex ores," and Mr. Johnson believes that "the great importance of a process that will *save the zinc* is manifest." Mr. Austin calls attention to the obstacles presented by zinc in the smelting process, and comments on its loss and that of accompanying metals.

5.—When we come to consider what processes may be regarded as possible solutions of the complex-ore problem, we find the greatest diversity of opinion. Excluding those opinions emanating from contributors personally interested in some process, we find two features among the balance: an expression of hope and confidence in the ultimate success of electric zinc smelting, and a favorable attitude toward hydrometallurgy.

Mr. Wiard alone anticipates that "mechanical processes will be more generally applied in the treatment of these ores." Others express more conservatively the thought that mechanical methods will hold their own for some time to come, because the newer proposals have not yet reached the stage of successful application and must await wide adoption until they have produced acceptable data from operation. It appears almost certain that in some cases preliminary mechanical concentration will have to accompany even hydro- or electrometallurgical schemes. Flotation is one of the newer mechanical methods in which some profess to see a hopeful solution in special cases; but even here, as Mr. Skinner points out, we are benefited only in the case of one-mineral separation. Where two or more sulphides are involved, flotation does not offer so much advantage.

In fact, in the whole realm of mechanical processes, it is not one, but two or more methods in combination to which we must look for economic ore-treatment. This "interminable mechanical grooming," as Mr. Croasdale puts it, is objectionable on the score of successive losses in each step; and its abandonment has been one of the chief incentives of those who advocate new processes to yield metals at the mine.

Mr. Ionides believes that "a solution of the problem along purely mechanical lines seems doubtful, and is inclined, with Mr. Bell, to think that "hydrometallurgical and chemical means will have to be employed." Others express similar sentiments. Mr. Clevenger is especially impressed with the possibilities of hydrometallurgy, which is coming to be of rapidly increasing importance and promises to be as useful in the recovery of non-ferrous metals as the cyanide process is for gold and silver. He sees in this line of development a possible solution of not only the complex-ore problem, but also the smelter-smoke problem. Obstacles to successful hydrometallurgy do not seem insurmountable to him in view of the remarkable work done at Cobalt in treating complex silver-cobalt-nickel-arsenic ores by cyanidation.

The objections to hydro- and electrometallurgy are voiced by Mr. Swart, who says that "plant cost on most of the proposed chemical and electrical methods is prohibitive for small mines," and by Mr. Skinner, who objects to "the handling of salts of high heats of formation in large volume of solution, calling for a high investment cost and demanding expensive chemicals."

Of the special processes proposed, Mr. Johnson is partial to electric smelting; Mr. Scibird and Mr. Ionides to some form of chlorination, and Mr. Bretherton to ammonia-carbon dioxide.

Speaking from the standpoint of a smelter, Mr. Austin is of the opinion that "it would be hazardous to suggest" along what line reduction methods will develop, but he believes it will be "not in the line of pyrometallurgy." It is interesting to compare this with the opinion expressed later by Mr. Clerc, whose experience leads him "to believe that there is an opportunity for the wider use of pyrometallurgical concentration" by modified forms of smelting or sintering. Mr. Clerc has in mind, as a particular case of the general problem, the lean oxidized ores of zinc and iron which, while not within the class of complex sulphides nevertheless present a problem of similar economic importance. These ores require some form of concentration in order to raise their zinc content to the grade required by zinc smelters. Not being amenable to any of the ordinary methods of enrichment, fire concentration is suggested. This would produce an impure zinc oxide for further reduction in a special furnace, and it is Mr. Clerc's suggestion to so modify current metallurgical practice as to enable the smelter to co-operate with the miner in utilizing this kind of ore.

6.—The general use of the microscope is commended in examining ores and products: to determine the fitness of the former for the proposed treatment and the efficiency of the process as indicated by the latter. Such examination will aid in locating trouble and may suggest the remedy. It will be specially valuable in the case of tailings, middlings and other products of wet and dry separation processes, and in observing changes in the character of the original ore supply. Several contributors to the symposium who are college professors state that they regularly train their students in this use of the microscope.

**General.**—The reader who is well posted on the subject of this symposium may feel that the tenor of the replies to our questions is about what he expected. At the same time it is worth while to have these opinions publicly expressed by competent observers, in order to crystallize the facts for the benefit of those less well informed. It is made clear that the problem is one of many phases. We cannot "use the same medicine for a number of widely different ills," as Mr. Haldane says. This is reason enough for considering the merits of all the various proposals and, above all, maintaining an open, unbiased mind. This is good advice to the promoter as well as the perspective user of new schemes. Panaceas are not favorably regarded by the well informed.

A useful hint to process inventors is given by Mr. Croasdale, who suggests that the best way to bring new processes to trial is to secure the support of operating companies that have the problem, the money and the willingness to spend it intelligently. "This can be readily done by appropriations set aside from earnings, which would virtually come from the properties themselves and not from the shareholders." Mr. Collins makes it plain, in this connection, that pioneer work in metallurgy is expensive, and that "the details of such processes (electric smelting or chlorination) should be worked out by large existing producers." The unfortunate tendency of small, inexperienced operators to try unproved processes is properly criticized by Mr. Godshall.

On the whole we believe that the symposium has given expression to many useful and constructive ideas, and has brought out strongly the spirit of willing co-operation which makes the ultimate solution of the problem seem far from hopeless. To all those who have contributed from their knowledge and experience, we express our thanks and hearty appreciation.

---

**The Titanium Alloy Manufacturing Company** announces that it has organized a Bronze Department for the manufacture of Titanium-Bronze Specialties under its various patents, and that Mr. Wm. M. Corse, formerly Works Manager of the Lumen Bearing Company, Buffalo, and lately General Manager of the Empire Smelting Company, Depew, N. Y., will be associated with the company as Manager of this department.

**A composition for treating boiler feed-water,** patented by Gilbert E. Bailey, of Los Angeles, Cal., consists of a mixture of graphitic iron and 1 to 4 per cent. zinc, the latter being added to the iron as it flows from a cupola. The alloy is turned into shavings or powdered.

**A new platinum alloy,** suitable for making scientific instruments, electrical contacts, and the like, has been patented by Exechiel Weintraub, of the General Electric Co. It consists of platinum and either tungsten or molybdenum, or the three together, platinum constituting about 20 parts of the whole. The alloy resists the action of air and has great mechanical strength.

**Transvaal Gold Production.**—The number of companies reporting to the Transvaal Chamber of Mines in March, 1914, was 60. The total quantity of ore milled during that period was 2,149,601 tons. There were 9662 stamps in operation, with an average duty of 8.82 tons per 24 hours. Tube mills in commission numbered 290. The yield for the month was 686,801 fine ounces gold.

# The Application of Physical Chemistry to Industrial Processes[*]

BY WALTER F. RITTMAN

The luxury of to-day is the necessity of to-morrow; likewise the theory of to-day is the practice of to-morrow. Gayley's process of drying air for a steel furnace, the various nitrogen-from-air processes, the contact process of manufacturing sulphuric acid, synthetic indigo, synthetic tanning materials—all were in the field of abstract theory but a few years ago. To-day they are practical realities. Similarly many of the theoretical principles and processes of to-day will in all probability be realities a few years hence.

The invasion of chemistry by physics and the production of what is known as physical chemistry, promises to be a most important basis for progress in the field of applied chemistry. Whereas physical chemistry is often looked upon as one of our most theoretical subjects, it will be found to be one of our most practical as well. Its principles are useful regardless of the materials involved in the reactions, whether copper, steel, soap, glass, cement, gas, textile, or any other chemical product. Physical chemistry is described as that branch of chemistry which has for its object the study of the laws governing chemical phenomena. When these laws and their application to a reaction or process are once understood it is a relatively easy matter to select the most favorable physical conditions. The task of the chemical engineer is to produce these most favorable working conditions in an apparatus which operates on an industrial scale. A further advantage of a knowledge of theoretical principles and perhaps one to be more frequently applied is the aid such knowledge gives in avoiding fantastic so-called improvements.

The chemical engineer rarely creates new products; he deals with processes and machinery which produce quantities economically. Obviously his problems often differ from those of the laboratory chemist. The fact that a reaction is slightly exothermic or endo-thermic is of secondary consequence in laboratory experiments, but in applied engineering this fact at once determines whether the reaction should be carried out in a cooled or in a heated apparatus. The amount of heat given off in a reaction, such as the hydrogenation of a vegetable oil, is of no serious consequence in laboratory experiments, but where tons are handled the accumulated heat is sufficient to ruin any process which does not provide for its disposal. Latent heat of fusion or of evaporation is not important in the laboratory where there is always an excess of heat or cold, but in many cases this heat of fusion or of evaporation becomes all important in its influence on the cost of an industrial operation. The cost of the heat absorbed by an endothermic reaction seldom concerns the laboratory chemist; but it is profit or loss to the chemical engineer. The percentage of yield, and the cost per unit, are the vital questions to the engineer; they are usually not vital to the laboratory chemist, however valuable and constructive his work may be.

It sometimes seems as if the inertia of years has limited the temperature imagination of many engineers and some chemists. Theoretical considerations might suggest the broad field which comprises the several thousand available degrees above the boiling point, as well as the 273 degrees below the freezing point of water. Likewise we are prone to overlook the great advantages which sometimes may be derived from the application of pressures greater or less than the one atmosphere which surrounds us and with which we are so familiar.

---

[*] A paper presented before the American Institute of Chemical Engineers, Troy, N. Y., June 17th, 1914.

Because of the numerous possibilities in the application of physical chemistry to industrial processes, I must greatly restrict myself in dealing with the subject. Some of the most interesting parts deal with equilibrium relationships, phase rule applications, radioactivity, energy considerations and electrolytic reactions. Excellent examples illustrating the successful application of each can be found, but to-day I shall deal in some detail only with the one mentioned first; i.e., equilibrium relationships.

I shall not attempt to deal with every branch of modern production which involves the equilibrium relations of physical chemistry, nor shall I attempt to advance speculations as to future applications of equilibrium relations in industry. The attempt will be confined to successful present-day applications, by way of examples. However familiar these processes may be, I hope that there will be at least something interesting, if not new, in pointing out that these familiar processes have a purely theoretical aspect. In fact, dealing with them historically indicates that they have all developed out of the most abstract theoretical reasoning into the practical machinery of economical production.

### Oxidation of Nitrogen From Air

It is known that at room temperature there is no perceptible union of the nitrogen and oxygen of air; it is known that at temperatures as high as 3000° C. only a partial union takes place; it is known that the amount which does unite is a function of the temperature. That is, at each temperature there is a definite percentage of nitric oxide formed, and equilibrium exists between the combined and uncombined constituents. In other words, the tendency of the uncombined constituents to combine at any particular temperature is exactly counterbalanced by the tendency of the combined constituents to separate at that temperature.

There is a true equilibrium. Experiment has proven that when air analyzing 79.1% $N_2$ and 20.9% $O_2$ is brought to equilibrium at 2400° C. the resultant mixture[1] analyzes 2.23% NO, 77.98% $N_2$ and 19.78% $O_2$, i.e., 1.115 per cent. of an atmosphere each of nitrogen and oxygen have disappeared in the formation of nitric oxide. Further let it be clear that this 2.23 per cent. of NO obtained at 2400° C. is not an accidental figure; it will always be the same when air of the above composition is brought to equilibrium at 2400° C.

This fact makes it possible to calculate the equilibrium constant for nitrogen, oxygen and nitric oxide at 2400° C.

$$N_2 + O_2 \leftrightarrow 2NO - 43{,}200 \text{ cal}$$

$$K_{2400°C} = \frac{p^2_{no}}{p_{n_2}\ p_{o_2}} = \frac{(0.0223)^2}{(0.7798)\ (0.1978)} = 0.0032$$

where $p$ represents the partial pressures of each of the three constituents, i.e., the part of the whole pressure exerted by each.

The constant K which joins these partial pressures has a definite numerical value for each definite temperature. The square of the partial pressure of NO, divided by the product of the partial pressure of $N_2$ multiplied by the partial pressure of $O_2$, for any mixture of these three constitutents in equilibrium at 2400° C. will be equal to 0.0032. Through the application of thermodynamic principles[2], it is possible to calculate the value of K′ for any other temperature from the above experimentally determined value of K for 2400° C.

From this value of K′ for any other temperature, as 3000° C. for example, it becomes a simple matter to calculate the yield of NO which will be obtained from any initial mixture of nitrogen and oxygen brought to equilibrium at that temperature. Percentages of $N_2$, $O_2$ and NO which satisfy the equilibrium relationship for any temperature will always be obtained when these constituents are brought to equilibrium at that temperature. Further, the reaction is reversible, and reaches the same results from either direction.

A number of values for equilibrium constants of this reaction at different temperatures have been calculated. From these values the percentage yield of NO from air have been calculated, and the calculations have been checked, as follows:[3]

TABLE I—COMPARISON OF CALCULATED AND OBSERVED VALUES OF EQUILIBRIUM CONSTANTS FOR THE $N_2 + O_2 = 2NO$ REACTION

| Temperature Degrees C. | NO (calculated from values of K) Per cent. | NO (observed) Per cent. |
|---|---|---|
| 1538 | 0.35 | 0.37 |
| 1604 | 0.43 | 0.42 |
| 1760 | 0.67 | 0.64 |
| 1922 | 0.98 | 0.97 |
| 2307 | 2.02 | 2.05 |
| 2402 | 2.35 | 2.23 |
| 3060 | 5.00 | .... |

It is observed that until 3000° C. is exceeded the yield of NO is below five per cent. The above clearly indicates how theoretical considerations show the limits of a reaction as well as the most favorable conditions for its industrial application. The oxidation-of-nitrogen process obviously is limited in practical application to localities where large quantities of cheap electric power are available.

### Contact Process of Manufacturing Sulphuric Acid

The contact process of manufacturing sulphuric acid, considered from the equilibrium view point, can be expressed by the equations:

$$SO_2 + \tfrac{1}{2}\, O_2 \leftrightarrow SO_3 + 22{,}600 \text{ cal}$$

$$K = \frac{p_{so_3}}{p_{so_2}\ p_{o_2}{}^{1/2}}$$

A few values[4] of K are given in Table II.

TABLE II—VALUES OF EQUILIBRIUM CONSTANTS AT DIFFERENT TEMPERATURES FOR THE $SO_2 + \tfrac{1}{2}\, O_2 \leftrightarrow SO_3$ REACTION

| Temperature Degrees C. | $K_p$ (experimental) |
|---|---|
| 400 | 580.0 (calculated) |
| 450 | 188.0 |
| 515 | 65.4 |
| 600 | 14.9 |
| 800 | 1.81 |
| 900 | 0.57 |

Upon calculating the maximum yields of $SO_3$ obtainable at the different temperatures from the various values of K, it is observed that the yield rapidly decreases as the temperature increases. This is in contrast to the nitric oxide illustration where the yield of NO from $N_2$ and $O_2$ increases with the temperature. As the temperature increases in the $SO_2 + O_2$ reaction the values of the equilibrium constants decrease rapidly. At temperatures below 400° C., however, the union of $SO_2$ and $O_2$ is too slow for an industrial process. At this temperature there is but a slight sacrifice of the percentage of $SO_2$ and $O_2$ combination.

---

[1] Nernst & Finckh, Z. anorg. Chem., 1905, p. 116; Ibid, 1906, pp. 212, 229.

[2] Nernst Theoretical Chemistry, seventh German Edition, pp. 675-6. Morgan, Elements of Physical Chemistry, 5th edition, in press.

[3] Nernst, Zeit, anorg. Chem., 1906, pp. 213-228. Zeit. f. Elek., 1906, p. 257, p. 529. Jellinek, Zeit. anorg. Chem., 1906, p. 229-276. Nernst-Finckh, Ibid, 1905, p. 116.

[4] Kuletsch, Berichte 1901, p. 4069. Bodlander u. Koppen, Z. f. Elek. 1903, p. 787. Bodenstein u. Pohl Ibid, 1905, p. 373.

Temperature, however, is not the only thing which influences a reaction of this nature. Without entering into a mathematical discussion of the influence of pressure, we can recall LeChatelier's principle: that pressure stimulates those reactions involving contraction, while vacuum encourages those reactions involving expansion.

Further, temperature and pressure do not complete the factors influencing chemical reactions where equilibriums are involved. The third and important factor is the relative concentration of the various reacting elements. The $SO_3$ reaction furnishes an excellent example showing the influence of the concentration of the combining reagents. Observing the mathematical expression for the equilibrium relationship,

$$K = \frac{p_{so_3}}{p_{so_2}\ p_{o_2}^{1/2}} \quad \text{or} \quad \frac{p_{so_3}}{p_{so_2}} = K\sqrt{p_{o_2}}$$

it becomes evident that the relative yield of $SO_3$, with respect to $SO_2$, increases as the partial pressure of oxygen increases, since the value of K for any given temperature does not change. This can best be observed by giving K the arbitrary value 200, and assigning to $O_2$ the partial pressures 0.25, 0.50, 1.00 and 2.00:

Then $\dfrac{SO_3}{SO_2} = 200 \times \sqrt{\text{partial pressure } O_2}$ and the ratios desired are given in Table III.

TABLE III—SHOWING EFFECT OF INCREASING THE CONCENTRATION OF ONE OF THE CONSTITUENTS IN AN EQUILIBRIUM

| Partial pressure of oxygen | Ratio of $SO_3$ to $SO_2$ |
|---|---|
| 0.25 | 100 |
| 0.50 | 141 |
| 1.00 | 200 |
| 2.00 | 282 |

This influence of an excess of oxygen is of practical value and is used in the commercial manufacture of $SO_3$.

### Synthesis of Ammonia from $H_2$ and $N_2$

Another illustration of the factors entering into chemical equilibriums involving temperature, pressure, and concentration is the Haber method of manufacturing ammonia from nitrogen and hydrogen[5]. The synthesis of ammonia from nitrogen and hydrogen depends upon the equilibrium represented by the expression:

$$\underset{\text{2 volumes}}{\tfrac{1}{2} N_2 + 3/2\, H_2} \leftrightarrow \underset{\text{1 volume}}{NH_3} + 13{,}000 \text{ cal}$$

$$K = \frac{p_{nh_3}}{p_{n_2}^{1/2}\ p_{h_2}^{3/2}}$$

A few investigated values for K are given[6] in Table IV.

TABLE IV—EQUILIBRIUM CONSTANTS FOR THE AMMONIA SYNTHESIS

| Temperature Degrees C. | K (experimental) | K (calculated) |
|---|---|---|
| 700 | ....... | 0.00068 |
| 800 | 0.00033 | 0.00036 |
| 1000 | 0.000148 | 0.000145 |

Haber[7] found that as the temperature rises above 500° C. the yield of $NH_3$ is low, while below 500° C. the rate of reaction is too slow. He eventually so perfected his experimental apparatus that his yields of $NH_3$ permitted him to calculate K from experimental data and compare the same with theoretical values. The close correspondence of the theoretical and actual values above indicate how experiment reinforced by theory will often show what can be expected in practice better than imperfect experimental results without theory. Without theory, in fact, Haber would never have known whether his experimental work was perfect, imperfect, or worthless.

In this ammonia reaction, equilibrium relations are such that when the reaction is practiced under atmospheric pressure the maximum yield is not sufficient to warrant industrial application. A yield of less than one quarter of one per cent. is of little more than scientific interest. Through the introduction of increased pressures, however, the contraction from two volumes to one volume is greatly favored and the process yielding twelve per cent. at once becomes of decided commercial interest. In the oxidation-of-nitrogen process, on the other hand, there is no change in the number of volumes, and pressure is without influence on the reaction. This pressure influence in connection with equilibrium relations is strikingly shown[7] in table V.

TABLE V—PERCENTAGE AMOUNT OF $NH_3$ IN THE EQUILIBRIUM OF THE REACTION $N_2 + 3H_2 = 2NH_3$

| Pressure in | Temperature Degrees C. | | | | |
|---|---|---|---|---|---|
| atmospheres | 550 | 650 | 750 | 850 | 950 |
| 1 | 0.0769 | 0.0321 | 0.0159 | 0.0089 | 0.0055 |
| 100 | 6.70 | 3.02 | 1.54 | 0.874 | 0.542 |
| 200 | 11.9 | 5.71 | 2,99 | 1.68 | 1.07 |

### Other Applications of Equilibrium Relations

The equilibrium relationship between reacting agents persists throughout all chemical phenomena. The relative amount of $CO_2$ to CO issuing from a furnace is primarily a function of temperature and pressure, and is influenced by the machine only insofar as the machine influences these variables. The equilibrium between $CO_2$ and CO in the presence of carbon for any temperature is reached regardless of whether one starts with CO or with $CO_2$, or with any mixture of the two.

$$CO_2 + C \leftrightarrow 2\, CO$$

$$K = \frac{p^2_{co}}{p_{co_2}}$$

TABLE VI[8]—EQUILIBRIUM RELATIONS BETWEEN CO AND $CO_2$ IN PRESENCE OF CARBON

| Temperature °C | Per cent by volume CO | $CO_2$ |
|---|---|---|
| 450 | 2 | 98 |
| 750 | 76 | 24 |
| 1050 | 99.6 | 0.4 |

Typical examples of this relationship are found in the kitchen stove, the factory boiler, the blast furnace, the gas machine or the open-hearth furnace. Doubling the size of the blast furnace changes the relative amounts of $CO_2$ and CO only so far as doubling the size of the furnace influences the temperatures in the various reacting zones. With increasing temperature the percentage of CO increases, with decreasing temperature the percentage of $CO_2$ increases.

In the blast furnace, for instance, not only are the CO and $CO_2$ in equilibrium, but the various oxides of iron are likewise in equilibrium with carbon, CO and $CO_2$, as well as with one another.

---

[5] *Zeitsch. f. Elek.*, 1913, p. 53.

[6] F. Haber, Thermodynamics of Technical Gas Reactions.

[7] F. Haber, *Jour. Soc. Chem. Ind.*, 1914, p. 49.

[8] J. Mellor, Modern Inorganic Chemistry, p. 713.

Consider the blast furnace reactions,

$$\begin{aligned} 2CO &\leftrightarrow C + CO_2 \\ Fe_2O_3 + CO &\leftrightarrow Fe_3O_4 + CO_2 \\ Fe_3O_4 + CO &\leftrightarrow FeO + CO_2 \\ FeO + CO &\leftrightarrow Fe + CO_2 \end{aligned}$$

from the equilibrium point of view; there is found to be a vital relationship between them. On first sight a series of equations of such a nature looks very complex, but on the application of equilibrium relationships, formulated by means of the phase rule diagram, it is found to be relatively simple and clear.

Experimental work[9] has been done on these relationships, from which it is possible to plot the diagram of equilibriums.

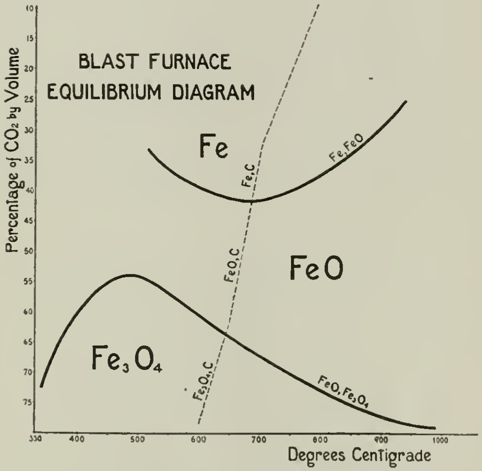


FIGURE I—BLAST FURNACE EQUILIBRIUM DIAGRAM, SHOWING RELATIONS BETWEEN C, CO, $CO_2$, Fe, FeO, AND $Fe_3O_4$

All of the reactions are reversible; their direction is entirely a function of temperature. From the diagram the fields of stability of Fe, FeO and $Fe_3O_4$ in the presence of CO and $CO_2$ for the temperatures shown can be observed. It can be observed, for example, that FeO at 650 deg. C. is not stable in the presence of more than 65% or less than 43% $CO_2$. It becomes evident that in the reduction of FeO to Fe a maximum of $CO_2$ in the flue gases is obtained when the reaction takes place at about 675 deg. C, and that this percentage of $CO_2$ decreases as the temperature increases. The diagram indicates that most of the reduction takes place in the cooler part of the furnace.

### Coefficient of Partition or Distribution

Equilibrium conditions also prevail in the more purely physical world as well as in chemistry. A solution which divides itself between two immiscible solvents will always be found in a definite concentration in both solvents, and there will always be a definite ratio between the concentration in each. This ratio is known as the partition or distribution coefficient.

I will cite first the laboratory example dealing with iodine, water and carbon disulphide. Iodine is slightly soluble in water and much more soluble in carbon disulphide, while water and carbon disulphide are practically insoluble in each other.

Suppose we have both water and carbon disulphide in one vessel and add some iodine. It has been observed from experiments that the concentration of iodine in the carbon disulphide is 588 times the concentration of iodine in water. In other words,

$$K_{iodine} = \frac{C_{cs_2}}{C_{h_2o}} = 588$$

In similar manner iodine divides itself between ether and water so that the concentration of iodine in the ether is 200 times the concentration of iodine in the water.

$$K_{iodine} = \frac{C_{ether}}{C_{water}} = 200$$

Similar examples can be found in the distribution of acetic acid between benzene and water, benzoic acid in benzene and water, succinic acid in ether and water, acetic acid in chloroform in water, saccharin in ether and water, acetanilid in ether and water, vanillin in ether and water, or acetanilid in chloroform and water.

This aspect of equilibrium is finding application in analytical chemistry, more especially in that branch dealing with alkaloids.[10] Through its application the haphazard washing out process in alkaloid work is replaced by one of mathematical precision.

Technical application can be found in Parke's process for extracting silver from lead. Silver is very much more soluble in zinc than in lead, whereas lead and zinc are only slightly soluble in each other. The lead containing silver is melted and thoroughly mixed with a small proportion of zinc. The zinc floats to the top, carrying with it in solution practically all of the silver, and on cooling solidifies while the lead is still molten. The zinc containing the silver is then skimmed off, and these two constituents separated.

Lack of time forbids the consideration of the equilibrium relationships existing in the ionization of acids, bases, and salts. Their application in analytical chemical methods is to-day a reality, their technical application promises much.

### Equilibrium Relations Are of General Application

The equilibrium or kinetic relationship is accepted and used by theoretical chemists, and is believed to prevail in practically all fields of chemistry. When considered in mathematical units it changes qualitative suggestion into quantitative information. Equilibriums deal with yields in terms of percentages or weights, they deal with temperature, pressure and concentration in numerical terms. When so applied, they are concrete and cease to be more theoretical than any other mathematical statement.

Equilibriums exist between reacting agents in solution; between reacting liquids; between liquids and vapors; solids and liquids; solids and gases; between gases which react chemically; between the concentrations of a solute divided between two immiscible solvents; in the ionization of acids, bases and salts, in hydrolysis and saponification; in fact in all the chemical and physical phenomena with which the chemist or the chemical engineer deals. The industrial development and application of physical chemistry, including this equilibrium principle, is only partially realized to-day; its further development and application seem to depend largely upon competition and necessity, and the stimulus they offer to the inventive faculties of chemical engineers as the leading specialists in this most promising field of our science.

Chemical Engineering Laboratory,
Columbia University, New York.

---

[9] Baur und Glaessner, *Zeit. physik. Chem.*, 1903, p. 354.

[10] J. W. Marden, Jour. of Ind. and Eng. Chem., 1914, p. 315.

## Recent Chemical and Metallurgical Patents

### Iron and Steel

**Method of Coating Iron with Zinc.**—In the manufacture of galvanized pipes for electric conduit purposes, Mr. **Peter McIlroy**, of Pittsburgh, Pa., has patented an improved process which he has assigned to the Enameled Metals Co., of Sharpsburgh, Pa. The pipe is successively immersed in alkali, acid and lime baths to prepare it for the coating of zinc. The electroplating is accomplished in two operations: first, by depositing a "strike" coat of copper and zinc in the proportion of 40 per cent copper and 60 per cent zinc; and second, by applying over this a coating of zinc. The inventor claims that this improved "strike" coat enables him to produce a coated pipe that will not be subject to corrosion. Pipe thus prepared is whiter and more uniform in appearance than other similarly coated pipe. (1,096,636, May 12, 1914.)

### Gold and Silver

**Continuous Slime Thickening Apparatus.**—In Fig. 1 is shown an apparatus patented by Mr. **John E. Rothwell**, of Butte, Mont., and assigned to the Colorado Iron Works Co., of Denver, Col. The object of the device is to continuously thicken a slime pulp, as in the cyanide process for gold and silver recovery, and to separate clear solution from the thickened pulp. The apparatus comprises a hollow cylinder 3, open top and bottom, supported in a cylindrical vessel with a conical bottom. An air lift is centrally disposed in the tank, having a receptacle at its upper end into which the lifted pulp is discharged, and from which it may be diverted through gates into a launder 12 or back into the inner cylinder. An overflow launder 9 surrounds the upper edge of the tank, to receive clear solution after it has been separated from the thickened pulp.

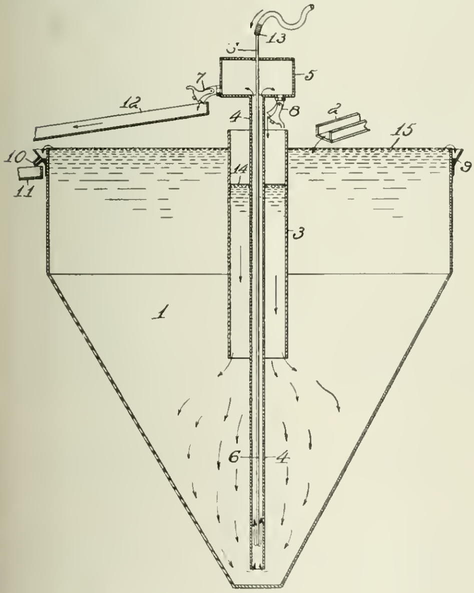


FIG. 1—CONTINUOUS SLIME THICKENER

In operation, a mixture of fine solids suspended in liquid is fed into the tank through the launder 2. The solids settle and the solution overflows. The settled solids accumulate in the cone and are elevated by the air lift. The latter is operated at a greater capacity than is necessary to supply the amount drawn off through launder 12, and this part returns to the cylinder 3. By this means the thickened pulp is kept in circulation and is prevented from accumulating in hardened masses on the conical side of the tank. A diaphragm pump may be used in place of the air lift. An application of the invention is to continuous decantation in the cyanide process, wherein thickened pulp of uniform density is withdrawn from the decantation vessels. (1,099,396, June 9, 1914.)

**Filter Leaf and Process of Dislodging Slime Cakes.**—A filter leaf from which the slime cake can be dislodged by means other than the application of reverse or internal fluid pressure, has been patented by Mr. **George W. Shepherd**, of New York City. The patent is assigned to the Butters Patent Vacuum Filter Co. In Fig. 2 is shown a side and end view of the leaf, and a plan of the water pipes used for dislodging the cake. The leaf consists of the usual pipe frame 5, perforated along the lower side and connected at 6 with a source of vacuum. A sack of filter fabric surrounds the frame and contains the customary slats 8, between which the two faces of fabric are stitched together as shown at 9. The upper edges of the fabric are held between the headers 16, bolted together at 15. Extending lengthwise of the frame, below the headers and outside the fabric are the pipes 1 and 2, slotted or perforated as at 10. These pipes join in a fitting 14 and are connected with a source of water under pressure. As shown by the dotted outline in the end view at the right, these water pipes are covered by the cake when it is formed on the fabric. After the cake has been formed and washed and is ready to be discharged, water is forced into the pipes 1 and 2 and directed by the slot or perforations between the cake and fabric, thereby causing the former to fall off. The feature of the patent is the admission of fluid beneath the surface of the cake. (1,096,132-3, May 12, 1914.)

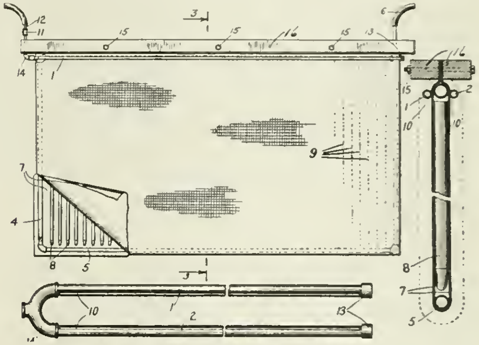


FIG. 2—FILTER LEAF

### Zinc, Lead and Copper

**Separation of Bismuth from Copper**—Mr. **William Thum**, superintendent of the lead refinery of the United States Metals Refining Co., Grasselli, Ind., has patented a process for the recovery of bismuth from the by-products of lead refining. The process is applicable also to bismuth-bearing refuse material, oxide slags from the treatment of bismuth-bearing copper, flue dust of copper furnaces and converters and from anode slime from electrolytic lead refining from which the antimony, arsenic and lead have been cupelled. Any material showing a concentration of bismuth in the presence of copper can be treated by the process, which consists in converting the copper into matte by fusing with an alkali sulphide, leaving the bismuth as metal which can be treated electrolytically.

The material containing bismuth and copper is first oxidized, crushed and mixed with an alkali sulphide, or preferably with an alkali sulphate and carbon. Salt cake and coke breeze are suitable materials. The mixture is smelted in a reverberatory furnace provided with a cupelling breast that can be scraped down to follow the level of the charge. The fluxing ingredients are added in amount equal to about two and one-half times that indicated by the theoretical requirements for reduction and conversion of metals and salts. When the mass is fused and in a perfectly liquid state it consists of three layers: on top is the soda slag, in the middle the copper matte, and beneath is the bismuth. Gold and silver, if present, are mainly in the bismuth, but some will be in the matte. The slag and matte are drawn successively, leaving the bismuth metal. If it now contains less than 1 per cent copper, it may be cast into anode bars and refined. If the copper exceeds 1 per cent, the metal is again converted to oxide by blowing air through it and the oxide slag is skimmed over the cupel breast. This material is then again crushed and smelted with fluxes as before. If the bismuth contains considerable gold and silver, this reoxidiation process may be performed for the purpose of recovering the precious metals, stopping the oxidation when but little bismuth remains and recovering the residue, which consists of a rich gold-silver-bismuth bullion. (1,098,854, June 2, 1914.)

### Rare Metals

**Extraction of Uranium, Vanadium and Radium from Ores.**—Among the numerous proposals made for treating radium-bearing ores is that of Mr. **J. H. Burfeind**, of Nucla, Col. He claims that the treatment of carnotite (uranium-vanadium-radium ore) with sulphurous acid will yield a solution of uranium and vanadium, and a precipitate of radium-bearing material. His method is to agitate ground ore and water with sulphur dioxide, whereby uranium and vanadium are dissolved, and barium and radium precipitated as a fine slime. By allowing the gangue to settle for a brief interval after agitation, he claims that the barium-radium precipitate remains suspended in the uranium-vanadium solution and can be decanted with it. By passing the liquid through a filter press the radium precipitate is retained and the solution clarified. The latter is then heated to drive off sulphur dioxide, whereupon the sulphites of uranium and vanadium are precipitated, recovered and subjected to any further treatment desired. The radium precipitate also is subject to further refining. (1,095,377, May 5, 1914.)

**Ductile Tungsten.**—A method for preparing bodies of tungsten, molybdenum and similar refractory metals which can be drawn, bent and otherwise worked, is patented by Messrs. **Paul Schwarzkopf** and **Siegfried Burgstaller**, of Berlin, Germany. The operation is performed in two steps and consists of a combined reducing and sintering process. Tungsten oxide in powdered form is compressed into rods, producing relatively strong and coherent pieces of metal oxide. These rods are then subject to a temperature of 1100 to 1150 C. in a stream of hydrogen, with the result that the material is sintered and partly reduced. The next step is to heat the rods by a current of electricity in an atmosphere of hydrogen at a temperature of 2600 to 2700° C. The resulting rods are ductile and can be bent into a ring at red heat. (1,096,464, May 12, 1914.)

### Ammonia

**Ammonia from Calcium Cyanamid.**—For the production of cyanamid first calcium carbide is made in an electric furnace; this is ground fine and charged into the cyanamid oven, where it is caused to react with nitrogen, forming calcium cyanamid, $CaCN_2$. This cyanamid carries about 60 per cent. calcium cyanamid, about 25 per cent. lime, 12 per cent. graphite, and other impurities in minor quantities, derived principally from the presence of foreign materials in the lime and the reducing agent used in the carbide furnace. If such cyanamid is treated with steam, at a high temperature, the calcium cyanamid is broken up with the evolution of ammonia, $CaCN_2 + 3H_2O = 2NH_3 + CaCO_3$. The ammonia is evolved as a gas and there is left behind in the treating apparatus a sludge consisting of calcium carbonate, calcium hydrate, graphite and impurities. On account of its physical condition this sludge could not be economically treated again in the carbide furnace in the past. This is made possible, however, by an invention of **Kenneth F. Cooper**, of the American Cyanamid Co., of Niagara Falls, Ont., Canada. If in preparing the cyanamid for treatment with steam a small quantity of an alkaline or alkali salt (1 to 2 per cent equivalent of $Na_2O$ in per cent of weight of cyanamid decomposed) is added, it affects in no way materially the evolution of ammonia, but when the resulting sludge is burnt in a rotary kiln or other calcination furnace, a porous clinker is produced of suitable size for carbide furnace charges. (1,100,539, June 16, 1914.)

### Caustic and Chlorine

**Sodium Chloride Electrolysis.**—Mr. **Herbert H. Dow**, of the Dow Chemical Company of Midland, Mich., patents a diaphragm cell for the production of caustic soda and chlorine from brine solutions. The carbon anode is enclosed in a dome which covers one-half of the cell and extends downward some distance below the normal level of the liquor. The chlorine gas accumulates within the dome from which it is withdrawn. The cathode is provided in the form of a horizontal wire mesh in the open portion of the cell. A horizontal diaphragm forms automatically below the cathode by the precipitation of the insoluble hydrates of the impurities in the solution. (Patent 621,908, March 28, 1899.) The solution containing the cathode above the diaphragm is always pure sodium chloride, while impure brine is used as anolyte. (1,100,290, June 16, 1914.)

---

## Synopsis of Chemical and Metallurgical Literature

### Gold and Silver

**Assaying for Gold and Platinum Metals.**—The assay of precious metals existing in black sand, concentrates and "battery chips" from South African mills has attracted the attention of chemists in that country, resulting in the publication of a number of papers on the subject. In our issue for November, 1913, page 652, we reviewed two methods bearing on the subject. In the *Journal* of the Chemical, Metallurgical and Mineralogical Society of South Africa, February, 1914, Mr. Andrew F. Crosse makes a further contribution to the subject, believing that it is important to ascertain to what extent platinum and allied metals are being lost to the producers by being sold as gold bullion. His method for gold, platinum and osmiridium is as follows:

Having obtained lead buttons from the ordinary crucible assay, they are cupeled with the addition of

2 to 4 mg. silver. This large quantity of silver is advisable when much iridium is present. Having obtained a bead of silver from the cupelation, proceed as follows: Melt some pure cyanide of potassium in a porcelain crucible over a Bunsen burner, having the crucible about half full. Add metallic cadmium to the amount of three times the weight of the silver bead to be treated, and when the cadmium is melted and can be plainly seen through the molten cyanide, drop in the silver bead. It quickly alloys with the cadmium, and the crucible is given a rotary motion to insure thorough mixing of the alloy. Pour the melt into a warm mold, recover the alloy by dissolving the cyanide in hot water and digest the metal in dilute $HNO_3$ (1:3). Cadmium and silver dissolve, leaving the other metals as a black powder. Filter, wash and burn the residue in a platinum dish at low temperature. Melt the residue with 10 g. acid potassium sulphate to dissolve rhodium and palladium if present. Digest the melt in warm water, filter and wash. The residue contains gold, platinum and osmiridium. Dissolve in aqua regia, obtaining gold and platinum in solution and osmiridium as a black residue, which is filtered, washed, calcined and weighed. The filtrate is evaporated twice to dryness in a porcelain dish, with addition of a few drops HCl each time. Dissolve in water and precipitate gold with $SO_2$. Filter and cupel the gold with lead. Precipitate platinum from the filtrate by acidifying with HCl and adding magnesium wire or ribbon. Filter, wash, calcine and weigh. The author states that he has made synthetical tests with gold and platinum and has obtained good results. In the discussion which followed the presentation of the paper, Prof. G. H. Stanley stated that he doubted if iridium is collected in the lead button in the ordinary crucible fusion. He believes that some of it goes into the slag, and that several re-assays of the slag may be necessary to collect all of it. He also stated that iridium is not easily filtered, even with the best papers. Mr. W. Cullen was of the opinion that the rarer precious metals existed in concentrates in sufficient quantity to make it worth while extracting them instead of allowing them to go out in gold bullion.

### Zinc and Copper

**Electrolysis of Fused Material Containing Zinc.**—A thesis by Mr. **Chun Hao Wang** presented for the degree of Ph.D. at Columbia University, contains an account of an experimental investigation carried out under the direction of Prof. E. F. Kern, on the freezing points of different zinc salt mixtures and the solubility of zinc sulphide and oxide in them. A longer review of this work is reserved for our next issue.

**Leaching with Dorr Classifiers at Butte & Duluth Mine.**—The use of modified Dorr classifiers in leaching oxidized copper ores is described by Mr. **C. S. Herzig** in *Bulletin* No. 116, Institute of Mineralogy and Metallurgy. Before adopting the present system the ore was treated by crushing to ½-in. and leaching for 48 hours in lead-lined vats with a 10 per cent sulphuric acid solution, following by a wash with water. The solution was precipitated by electrolysis or on iron. In order to improve extraction, experiments were made with Dorr classifiers in which wooden parts replaced metal that would come in contact with the acid solution. The first results were favorable, and the system finally adopted was as follows: The classifiers are 8 ft. wide and 30 ft. long, placed in series, the discharge of one falling into the next. The first four are for acid treatment and the last two for water washing. About 60 minutes' contact with acid is allowed. The ore is crushed to 10-mesh and is fed to the first classifier with solution from the first washing classifier. The overflowing slime passes to a vat beneath and is filtered through a bed of crushed ore. The coarse pulp progresses regularly through the line of classifiers. From the second, third and fourth machines, solution is drawn for precipitation by electrolysis. From the fifth the solution is used to mix with the original ore entering the first, and from the sixth the solution passes to precipitation on iron. Ten per cent sulphuric acid is used. The copper solution coming from the classifiers contains about 6 per cent acid and 4 to 5 per cent copper. Leaving the electrolytic plant, the solution contains about 8 per cent acid and 1½ to 2 per cent copper. Earthenware pumps have proved superior to lead-lined in handling the acid solution. Hickory, maple and glass teeth have been tried on the classifiers, but maple and hickory have proved best.

### Smelting

**Handling Flue Dust.**—The difficulty sometimes experienced in handling flue dust from blast furnaces prompts Mr. **Erle Huntley** to describe a simple method used for this purpose at the Hampden Cloncurry Copper Smelting Works, North Queensland. His paper appears in *Bulletin* No. 115, Institute of Mineralogy and Metallurgy. The furnace gases at this works are discharged into a collecting flue 9 ft. high and 7 ft. wide, and thence into a main settling flue 27 ft. high and 18 ft. wide. The increased area of this latter flue reduces the speed of the gas to about 240 ft. per minute. No baffle plates are used. The bottom of this flue is in the form of a trough, along which runs a ⅝-in. endless chain drawn by a sprocket wheel operated by a motor. The chain passes through the flue and returns along its top, being supported by pulleys. The chain travels at the rate of 40 ft. per minute, and is operated 6 hours per day. This suffices for the removal of about 12 tons flue dust, which is delivered into a collecting hopper in the bottom of the flue. In discusssing this paper (*Bulletin* No. 116) Mr. **T. C. Cloud** suggested that the attachment of discs to the chain would be more effective. No mention being made as to the method of closing the flue where the chain passed through its walls, Mr. **Cloud** suggested that if discs were used the chain might pass through tubes just about the diameter of the discs and long enough always to insure the presence of two discs in the tube, thus keeping the openings closed to the admission of outside air. Mr. **S. J. Speak** questioned whether dust losses by way of the stack could be avoided when the gas had a velocity of 240 ft. per minute, or 4 ft. per second, as it had been his experience that appreciable loss occurred at this velocity.

### Crushing and Grinding

**Kick's Law of Crushing.**—Mr. **S. J. Speak** makes a further contribution on the subject of crushing and grinding, giving in *Bulletin* No. 116, Institute of Mineralogy and Metallurgy, his views on the application of Kick's law to the measurement of energy consumed in crushing. Kick's law is stated by Stadler as follows: "The energy required for producing analygous changes of configuration of geometrically similar bodies of equal technological state varies as the volumes or weights of these bodies." Mr. Speak points out an important limitation to the correctness of this law, in that it assumes that the tenacity of a material is a constant quantity. This assumption is true for sizes appreciable by the naked eye, but does not hold good for fine sizes. He cites the enormous increase in tenacity in fine threads of spun glass and metallic wire, and shows that Kick's law becomes more and more inaccurate as sizes of rock or ore become finer. Another point of limitation is that ore is not a body of "equal technological state." It may contain vugs filled with soft, powdery material, or cracks filled with clay. The first fractures will take place along cleavages and weak places. Consequently the tenacity of a piece of such ore 4 in. in diameter will be much less than of a piece 1/10 in. in diameter. Further, much of the ore may be converted into slime without the expenditure of much energy. In general, the author comes to the following conclusions regarding the applicability of Kick's law, believing that they are borne out by actual experience.

1. It will tend to overestimate the energy consumed in coarse crushing.

2. It will tend to underestimate the energy consumed in grinding non-slimy sand to slime.

3. It will tend to overestimate the work done in making slime from such ores as contain slime as an original constituent.

**Graphic Record of Screen Analysis.**—In order to convey quickly to the mind the results of a screen analysis of crushed ore, Mr. S. J. Speak has shown in *Bulletin* No. 116, Institute of Mineralogy and Metallurgy, a method for graphically recording the results. Fig. 1 shows the graphic record of the figures given below:

| Screen Mesh | Aperture Inches | Percentage in Tube Mill Feed | Percentage in Tube Mill Discharge |
|---|---|---|---|
| + 12 | 0.03937 | 27.6 | ... |
| + 20 | 0.02480 | 15.7 | ... |
| + 30 | 0.01562 | 13.7 | 7.4 |
| + 50 | 0.00984 | 19.9 | 22.5 |
| + 80 | 0.00620 | 15.5 | 29.0 |
| + 120 | 0.00391 | 2.0 | 6.0 |
| + 200 | 0.00246 | 1.6 | 7.7 |
| — 200 | ...... | 4.0 | 27.4 |

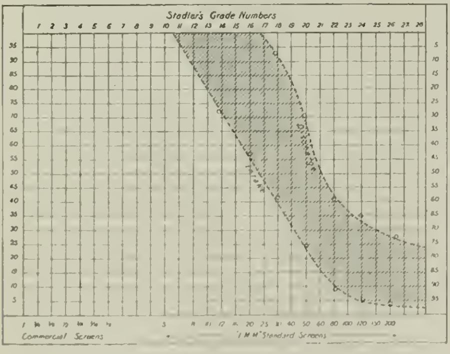


FIG. 1—GRAPHIC RECORD OF SCREEN ANALYSIS

Referring to Fig. 1, the left-hand lower portion of the diagram represents the energy already expended on the ore, and the right-hand upper corner shows the work remaining to be done to reduce the ore to the finest grade. The shaded portion represents the useful work done by the tube mill, which can be measured more readily and satisfactorily than by the mathematical method used by Stadler.

## An Economic Way to Handle Shipment of Long Iron Rods

The recent installation of a Shaw electric crane at the plant of the Bayonne Bolt & Nut Company of Bayonne, N. J., illustrates in a pretty manner how a difficult problem of handling material was solved by the application of a few small strands of wire.

The Bayonne Bolt & Nut Company receive quantities of bar stock-iron rods about twenty feet in length, and ranging in diameter from one-quarter inch upward. This raw material comes in gondola cars on the company's private switches.

The unloading and stacking of the rods by hand was, however, a slow process. The rods had to be lifted, one at a time, from the cars and carried to various parts of the yard. From the flexible and yielding nature of the material the "stocking" of a shipment was necessarily slow and, of course, expensive.

In seeking a better way to do the work an electric crane and magnet naturally suggested themselves, but the nature of the material to be handled again interposed an obstacle. With the rods lying loosely in the car a hoisting magnet could not pick up a clean load. Some rods would hang and swing. To obviate this, the expedient of having the consignors wire the rods together in bundles was adopted. With the rods in bundles it became possible to employ an electric crane and a magnet economically and the apparatus was installed by the Shaw Electric Crane Company. With the bar stock in bundles the magnet makes a clean lift not merely of one bundle, but of bundles up to its lifting capacity.

ELECTRIC CRANE FOR HANDLING IRON RODS

They are raised out of the car and piled practically at one operation. With the crane and magnet the company can now accomplish in a few minutes work which under the old method took a gang of freight handlers hours to do.

There is besides the saving in labor a gain in the speed of handling raw material. Furthermore, the use of the crane permits the piling of rods to a greater height than would have been economically possible by hand work.

## Filter Press Experience in a Cuban Sugar Plant

In our Vol. IX, page 381 (July, 1911), we noticed some interesting development work on filter presses carried out by Mr. John J. Berrigan, and in our Vol. XI, page 286 (May, 1913), we stated that the Berrigan filter press has been taken over by the Hy. R. Worthington Pump Company, of Harrison, N. J. The following report of the commercial operation of a Worthington filter press at Central Armonia, Bolondron, Cuba, should be of particular interest.

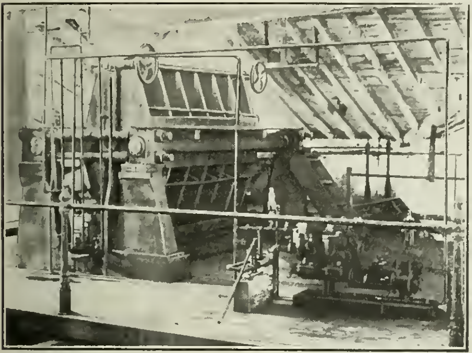
In actual continuous operation during the past crop for over a month at the Central Armonia for filtering cachaza, the Worthington filter press is stated to have shown the following advantages over the old-style frame presses in use in Cuban mills.

1. *Greater Efficiency.* A great saving of time is effected in the opening and closing of the press; in the dropping of the press cake and the placing of the filter

bags, as well as a great saving of labor expended. This permits of the press being idle but a very small percentage of the time.

The average capacity of the press may conservatively said to be at least 400 gal. of cachaza per hour. One press will do practically the work of four thirty-frame presses, rated at 1/3 m filtering surface per frame.

The filter bags can be used several times over without washing. On one test at the Central Armonia, the same set of bags was used continuously for fifty-six hours without washing.



WORTHINGTON FILTER PRESS IN CUBAN SUGAR PLANT

The simplicity of operation allows the employment of ordinary unskilled labor, there being no danger of breakage or of getting the press out of order.

2. *Economy in Operation.* Three men are sufficient to operate a battery of three presses which is sufficient to filter the cachaza resulting from a daily grind of 80,000 arrobas (1000 tons) of cane, including the washing of the bags, thus reducing from one-half to two-thirds the labor cost of operating the old-style frame presses.

3. *Saving in Material.* As but three bags are used in the filtering process a great saving is effected in filter cloth material used. Five sets of bags should be ample to make a crop, at a total cost of about $100 per press for material. Therefore, on the basis of a mill grinding 80,000 arrobas of cane every twenty-four hours and with three Worthington presses in use for filtering the cachaza, the total cost for filter cloth material should not be over $300 for the crop, as against a cost of from $1,000 up for filter cloths needed in operating the old-style frame presses.

There is very little tearing of the bags, which eliminates a considerable expense for repair of filter cloths.

4. *Better Results Obtained in Filtered Juice and Press Cake.* The juice is filtered perfectly, a brilliant liquor resulting, and entirely free from all small particles of fiber and other materials detrimental to elaboration.

The press cake is always well formed and can be removed from the bag very easily. The press cake shows from 10 per cent to 20 per cent less sucrose content than that shown in the cake resulting from the old-style frame presses under equal conditions.

5. *Economy for Repairs.* As there are no parts about the press than can be easily broken, the expense of replacing broken plates and frames is eliminated. The cost of upkeep on the press is practically negligible.

In Table I data are given as to the actual results obtained in operation of the Worthington filter press at the Central Armonia, during the crop just ended.

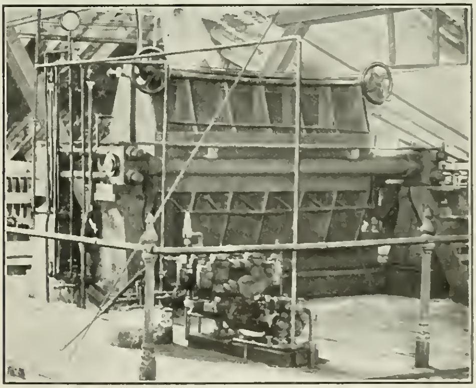
TABLE I—TESTS RUN AT CENTRAL ARMONIA WITH WORTHINGTON FILTER PRESS

| | 1 | 2 | 3 | 4 | 5 Av. |
|---|---|---|---|---|---|
| Minutes required to fill bags with cachaza | 3.5 | 2.5 | 3.0 | 2.0 | 2.75 |
| Minutes required to close press and make seal | 2.5 | 3.0 | 3.5 | 4.5 | 3.38 |
| Minutes required lowering press without pressure | 6.5 | 7.0 | 14.0 | 12.0 | 8.88 |
| Minutes required to close press under hydraulic pressure | 21.0 | 29.0 | 17.0 | 10.0 | 19.25 |
| Minutes required to raise press and drop bags with cake | 9.0 | 3.5 | 3.0 | 3.5 | 4.75 |
| Minutes required to put in empty bags | 4.0 | 4.0 | 6.0 | 6.5 | 5.12 |
| Total minutes required for complete operation of press | 46.5 | 49.0 | 46.5 | 38.5 | 45.13 |
| Gallons of cachaza per charge | 291 | 304 | 290 | 278 | 291 |
| Gallons cachaza filtered per hour (rate) | 375 | 372 | 374 | 433 | 388 |
| Degrees Brix of filtered juice | 9.75 | 14.4 | 10.7 | 13.8 | 12.16 |
| Percent Sucrose of filtered juice | 8.10 | 12.6 | 9.1 | 11.9 | 10.42 |
| Percent purity of filtered juice | 83.2 | 87.2 | 85.1 | 86.5 | 85.50 |
| Pounds of press cake | 184 | 192 | 168 | 172 | 179 |
| Percent Sucrose in press cake | 5.4 | 7.0 | 6.4 | 7.2 | 6.85 |
| Percent moisture in press cake | 58.2 | 58.4 | 57.8 | 59.3 | 58.42 |
| Thickness of cake in inches | | | | | ⅝ |

The above tests were conducted under circumstances somewhat unfavorable to obtaining the most advantageous results as to the maximum efficiency of the press. With an installation of the press in a manner to allow of time saving, in the filling of the bags with cachaza, dropping the bags with cake and putting in of empty bags, the time required for complete operation of the press could be reduced from the above figures.

The press in action had 300 ft. of filtering surface.

The comparison made in Table II of the Worthington filter press with one of the latest type cylinder presses in use in some sugar factories will prove of considerable interest.



WORTHINGTON FILTER PRESS IN CUBAN SUGAR PLANT

TABLE II

| | Worthington. Average | Late Type of Cylinder Press. Average |
|---|---|---|
| Total minutes required for complete operation of press | 45.13 | 160 |
| Gallons of cachaza per charge | 291 | 750 |
| Gallons of cachaza filtered per hour (rate) | 388 | 280 |
| Degrees brix of filtered juice | 12.16 | 14.5 |
| Percent sucrose of filtered juice | 10.42 | 11.1 |
| Percent purity of filtered juice | 85.50 | 76.6 |
| Percent sucrose in press cake | 6.85 | 8 |
| Percent moisture in press cake | 58.42 | 79.2 |
| Thickness of cake in inches | ⅝ | ⅝ |

## Electric Annealing Furnace for Brass and German Silver Ware

An interheating electric furnace for annealing brass and German silver flat ware blanks has just been installed in the plant of one of the best known makers of plated ware in this country, located at Niagara Falls, New York.

The furnace framework is made of steel shapes and plates, and is 15 ft. long, 8 ft. wide, 7 ft. 6 in. high. The doors are located at both ends of the furnace.

A mechanical pusher operated by compressed-air cylinders running over cast-iron idler sheaves operates the pusher mechanism located at the charging end of the furnace. The material under treatment is packed in steel pans 20 inches square which are forced through one after another, seven pans being in the furnace at one time. The pans passing through the furnace are supported by a hearth made of cast-iron grids 24 inches square, and are of special design, which prevents undue warping at furnace temperatures.

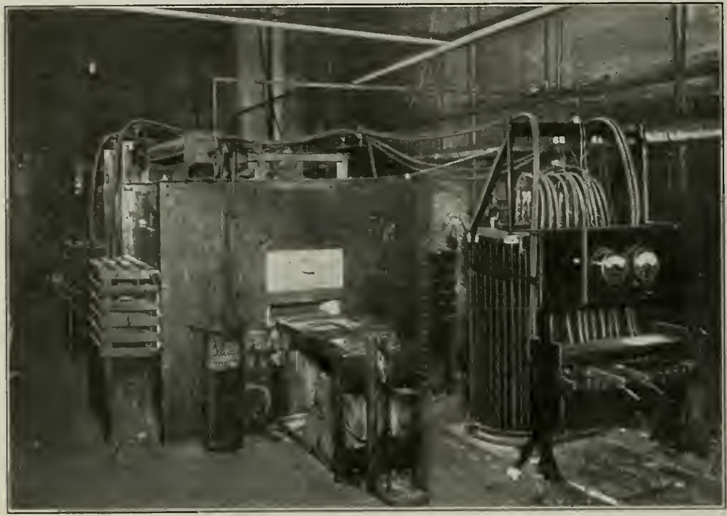


FIG. 1—FRONT END OF FURNACE AND ELECTRIC FURNACE

The pan coming out of the discharge end of the furnace is automatically dumped into a water-sealed discharge hood. The metal under treatment falls into a tank of either clear water or pickling solution, depending upon the cleanliness of the material before it is charged into the furnace. The pan itself is caught by two rails and held suspended above the trough and may be taken out from under the water sealed hood through the counter-balance swing door shown in Fig. 2.

The operation of the furnace is as follows:

A pan of flat ware is placed on the runway in front of the pusher—as shown in Fig. 1. The small hand lever shown near the top of the furnace frame in Fig. 1 is pushed upwards, which operates the air valve on the cylinder shown on the top of the furnace in the same figure. The first movement of the cylinder raises both the front and the rear doors to a sufficient height to admit the pans, which are 3 inches high.

At this point a stop on the cable holds the doors at this height and the pusher with the pan of fresh material starts into the furnace, pushing ahead of it the seven pans already in the furnace. At the moment the fresh pan is completely inside the furnace, the pan at the discharge end has been pushed clear of the furnace opening and door onto a dumping carriage. The weight of the pan striking the base of this carriage automatically tips the pan and it turns completely over, dumping the contents in a hopper, the lower end of which is submerged in the quenching tank. The pan, now upside down, is caught by two rails and held above the water and is taken out through the counter-balanced swing door shown in Fig. 2.

The material dumped into the quenching tanks falls into a perforated copper basket, which is lifted at intervals out of the quenching tank.

At the same time that the pan-dumping mechanism starts to tilt, the pusher carriage is pulled out of the charging end of the furnace by the counterbalanced door shown in Fig. 1, and immediately after the carriage clears the opening the two doors drop too, simultaneously. It will thus be seen with this furnace that the material is not exposed to the atmosphere at any time after entrance to the furnace until it is taken from the quenching tank cold. This entirely eliminates any possibility of oxidation at any stage during the heating or cooling, as the furnace itself has a reducing atmosphere at all times.

The electrical equipment consists of a special 200-kilovoltampere transformer, built by the Pittsburgh Transformer Company, and arranged with 12 voltage taps so connected to the special controller shown in Fig. 1. The switching mechanism is so connected with the transformer leads that a very fine regulation of the voltage, and hence the wattage, may be readily obtained. This switch is mounted on a switchboard frame and is located directly in front of the transformer, as shown in Fig. 1. The instruments on the switchboard panel consist of a Weston watt-meter and Foxboro pyrometer. The latter is connected up with a 48-inch couple placed directly over the pan about to be pushed out of the furnace, thus making it possible to know exactly at what temperature the material is drawn.

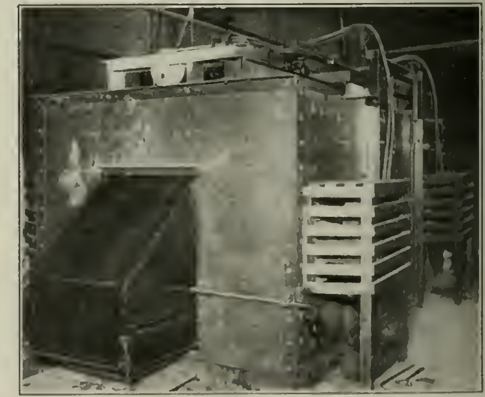


FIG. 2—DISCHARGE END OF FURNACE

The operation of this furnace has demonstrated clearly the superiority of continuous electric furnaces for the class of work handled, as the desired temperature may be reached with the utmost precision and without danger of overheating, and the ruling temperature at the end of the furnace is no higher than the temperature desired in the metal; and, further, the furnace atmosphere being always reducing and the material discharged from the furnace quenched from a sealed hood, eliminates the two most undesirable features usually found in fuel-fired furnaces; namely, lack of uniformity in temperature and oxidizing atmosphere.

This furnace was designed and installed by The Electric Furnace Company of America, Alliance, Ohio, who have recently received a duplicate order for a furnace of the same size and capacity for installation in the same plant.

## Personal

At the fiftieth anniversary of the Columbia School of Mines the honorary degree of Master of Science was conferred upon **John A. Church**, '67; **Wheaton B. Kunhardt**, '80; **Carl A. Meissner**, '80; **Arthur H. Elliott**, '81; **Francis B. Crocker**, '82; **J. Parke Channing**, '83; **Robert V. A. Norris**, '85; **Arthur S. Dwight**, '85; **Rudolph P. Miller**, '88; **Frederick W. Denton**, '89; **Karl E. Eilers**, '89; and **Gano Dunn**, '91; while the degree of Master of Arts was conferred upon **Henry F. Hornbostel**, '91 and **Goodhue Livingston**, '92.

Oberbergrat Professor Dr. **F. Kolbeck**, rector of the Bergakademie of Freiberg, Germany, was the official representative of Freiberg at the Columbia School of Mines celebration. He used the next few weeks for various trips to the Canadian cobalt district, Washington, D. C., the Franklin Furnace zinc mine, the Chrome (N. J.) copper refinery, etc. Before sailing for Europe he was the guest of honor at a dinner given by the Old Freibergers in America.

Dr. **Joseph W. Richards** has sailed for a professional and pleasure trip to Norway.

Professor **Hans Goldschmidt** of Essen-Ruhr, Germany, president of the German Bunsen Society and widely known as the inventor of the aluminothermic process and of electrolytic detinning, and Professor **Paul Askenasy** of the Institute of Technology of Karlsruhe, editor of the *Zeitschrift für Electrochemie*, were the guests of honor at an informal dinner given on June 8th at the Chemists' Club by the New York Section of the American Electrochemical Society. Dr. C. G. Fink, chairman of the section, presided and speeches were made by Dr. Baekeland, Dr. Goldschmidt, Dr. Askenasy, Dr. J. W. Richards, Dr. Alexander Smith, and Dr. C. F. Chandler.

Dr. **A. S. McAllister**, editor of *Electrical World*, has been elected president of the Illuminating Engineering Society.

Mr. **Charles F. Rand**, President of The Spanish-American Iron Company, Past President of American Institute of Mining Engineers, has been made a member of the Order of Isabella Catolica and decorated by the King of Spain with the Grand Cross of a Knight Commander.

Mr. **F. E. Pierce** has terminated his connection with The New Jersey Zinc Co. in whose employ he has served for over fifteen years in various capacities, for the latter part as chief engineer, and has opened an office to engage in consulting work in civil and metallurgical engineering at 35 Nassau street, New York City.

Mr. **H. W. Hardinge**, president of the Hardinge Conical Mill Company, has left New York for a combined business and professional trip which will include the Cobalt, Porcupine and British Columbia districts of Canada and Alaska, as well as the Western mining states. He will return in the second week of August.

Dr. **Richard Amberg** severed last January his connection with the Crucible Steel Company of America, where he was in charge of their new electric Heroult furnace, in order to accept the position of assistant manager of the Eisen-Industrie Menden-Schwerte, Germany.

## Digest of Electrochemical in U. S. Patents

PRIOR TO 1903.

*Arranged according to subject-matter and in choronological order.*

*Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.*

*Electroplating* (Continued)

349,535, September 21, 1886, Andreas Söhner, of Carlsruhe, Baden, Germany.

Relates to a process of renovating gold and silver lace trimmings, real or imitation, and consists, first, in dissecting the trimmings into their several parts, such as metal, and metal-coated fabrics, cleaning the parts by subjecting to the action of steam to soften and remove greasy and other impurities, then subjecting the articles to solutions of soda and Panama bark, to remove further traces of grease, etc., then to a solution containing hydrochloric acid to neutralize and remove the alkali, then to a brushing with tartaric powder, then to the action of a silvering or gilding bath, and then to a final polishing.

360,517, April 5, 1887, James E. Emley, of Weatherford, Tex., assignor to W. J. Carson and T. D. Lewis, both of same place.

Relates to apparatus for recutting files, and consists in connecting a file to one terminal of a source of current, a carbon plate to the other, and immersing the file and carbon in an electrolyte, such as sulfuric or other acid, or caustic potash, or salt water. A plurality of files may be so treated at once by connecting each file between a pair of carbon plates.

The patent does not state whether the file is to be connected as anode or cathode.

362,257, May 3, 1887, William L. Dudley, of Covington, Ky., assignor to the American Iridium Company, of Cincinnati, Ohio.

Relates to electrodepositing iridium. An electrolyte of either the double chloride of iridium and sodium, or the double chloride of iridium and ammonium is used, containing about two ounces of metal and about one-half ounce of free sulfuric acid to the gallon of solution. From both of these solutions a thick, bright and reguline deposit is obtained, using as anode either a plate of iridium or of phosphide of iridium, the latter made by the process described in patent 240,216, dated May 10, 1881. During the plating operation it is necessary to avoid a current of too great intensity, which causes a dark powdery deposit; alkaline solutions should also be avoided.

367,731, August 2, 1887, William Arthur Thoms, of London, County of Middlesex, England, assignor to the Bright Platinum Plating Company (Ltd.), of same place.

Relates to an electrolyte for electrodepositing platinum, from which a bright white deposit of a fine, close reguline nature is said to be obtained. The proportions of the electrolyte may be varied, but the following are said to give good results: One ounce of chloride of platinum, twenty ounces of phosphate of soda, four ounces of phosphate of ammonia, and one ounce of chloride of sodium, all dissolved in water and diluted to a gallon of solution. A strong current of electricity should be employed—states a current of twelve amperes at ten volts; fresh platinum solution and chloride of sodium should be added to keep up the original strength.

429,386, June 3, 1890, Myron W. Parrish, of Detroit, Mich., assignor to the Graphite Electric Company, of same place, and John Hutchinson, of Jackson, Mich.

Relates to separating impurities from native graphite, and consists in connecting pieces of graphite, before crushing, as an electrode and short-circuiting in an electrolyte of sodium chloride with an electrode of zinc. The impurity said to be generally present is iron, although other metals may be present.

434,884, August 19, 1890, Charles C. Peters, of Springfield, Ohio, assignor of two-thirds to John V. B. Hoyle, and Charles W. Wadsworth, both of same place.

Relates to recutting files by electrolysis. The files are connected as anodes, in parallel, using carbon, etc., as cathode. The electrolyte preferred is not stated, but should have the properties of normally feeble and slow action upon the iron or steel of the file, but which will become rapid and caustic under the influence of an electric current.

437,648, September 30, 1890, Myer Hecht, of New York, N. Y.

Relates to ornamenting wood, ivory, or other nonmetallic surfaces, such as umbrella handles, workboxes, etc., by suitably engraving or carving figures thereon, as by channeling, and undercutting the side walls at such points as are essential to hold the metal. The engraved or channeled portions are now treated with plumbago, iron fillings, etc., in order that metal may be electrodeposited therein. When completed, the deposited metal is ground smooth and then electroplated with the desired finishing metal.

448,144, March 10, 1891, Augustin Personne de Sennevoy, of Paris, France.

Relates to recutting files, rasps, etc., and also engravings on steel, copper, zinc or other metals, and to the re-etching of steel and copper plates, and to the renovation of damaskened articles. It consists in making the file, etc., the anode of a battery and short-circuiting with a carbon cathode in an electrolyte of one hundred volumes of water, six volumes of nitric acid and three volumes of sulfuric acid.

## Book Reviews

**The Steel Foundry.** By **John Howe Hall.** Octavo (15 x 23 cm.), 271 pages, 37 illustrations; price $3.00. New York: McGraw-Hill Book Company, Inc.

The book is written by an engineer thoroughly competent to write on the chemistry, metallurgy and engineering involved. It is eminently practical, in that it keeps the dollar mark thoroughly in evidence in the descriptions and discussions. A long chapter on general considerations is very interesting reading, as it summarizes and compares in a clear and convincing manner the advantages and disadvantages of each method of making steel for foundry purposes, including detailed analyses of costs. A very strong case is made out for electric furnace steel, which it is predicted will entirely replace crucible steel; the thermal efficiencies of electric furnaces, however, negative the statement that they are less economical of electric power than other furnaces are of fuel energy—the reverse is the case. Among the raw materials we note the omission of the soft iron sponge which is being made so cheaply and extensively in Sweden; and in the open-hearth furnace chapter no allusion is made to the combined producer and furnace so successfully used in Europe.

However, where there is so much that is valuable and good, and also original, it is perhaps captious to note these few defects. Perhaps still more unimportant are the frequent omission of the zero before a decimal number (e. g., .95 instead of 0.95), the use of such expressions as "15 per cent of manganese" for "15 per cent manganese," and some uncertainties of expression which come direct from the foundry. The work as a whole is worthy of hearty endorsement; it will be of great service to all engaged in making steel castings.

* * *

**Engineers' Hand-Book of tables, charts and data on the application of centrifugal fans and fan system** apparatus, including engines and motors, air washers, hot blast heaters and systems of air distribution. Published by The Buffalo Forge Company, Buffalo, N. Y. Edited by **Willis H. Carrier**, First Edition (1914), 581 pages. Price $3.00. Buffalo, N. Y. The Buffalo Forge Co.

This is in more than one respect a remarkable book. It is the first complete and reliable treatise on fans and their standard applications to various industrial requirements. It is intended to be used as a guide in the selection and appliction of fans, heaters and kindred apparatus, and an effort has been made so to standardize the rules and data given that they may be used with any standard make of equipment. A technical reference book of this kind is rarely prepared by a manufacturing company; that the Buffalo Forge Company has succeeded in bringing out a volume of so much technical value and absolutely free from talkative self-advertising, is a credit to its engineering staff and a fine indirect advertisement for the company itself.

The amount of information contained in this little handy volume which can be conveniently carried in the pocket is enormous. This was made possible by utmost conciseness in the text and by giving most of the technical information in the universal short-hand system of engineers, that is, in form of diagrams, tables and formulas.

In the first chapter (35 pages) data on the properties of air are collected (weight of air; specific heat of air; relation of velocity to pressure; effects of temperature, humidity and barometric pressure on the properties of air; relation of dry-bulb, wet-bulb and dew-point temperatures; sensible, latent and total heat; psychometric charts and tables).

The second chapter (65 pages) deals with the applications of fans (heating; ventilating; air washing, cooling, humidifying, drying, mechanical draft; exhaust systems; miscellaneous applications).

The third chapter on "air ducts" gives detailed information on the design of various duct or conduit systems used for the conveying of air. The data on pressure losses and friction in piping and elbows are based on actual tests, many of which were specially made for this book.

The subject of proper proportions of piping in different systems, as well as the proper velocity of air, is also completely covered.

In part IV (356 pages) on "apparatus" the products of the Buffalo Forge Co. and the Carrier Air Conditioning Co. are, of course, primarily covered. Since the essential elements in most installations, using fans, are the fan, heater ducts or piping system, and some form of motive power for driving the fan, this section gives complete data relative to the performance and dimensions of fans, heaters and engines, together with detailed directions for carrying out fan tests.

Data on the performance and dimension of cast iron heaters are also given.

An appendix gives specifications and various reference tables for engineers.

The editor and publisher must be sincerely congratulated.

# Metallurgical and Chemical Engineering

A Consolidation of Electrochemical and Metallurgical Industry and Iron and Steel Magazine

Vol. XII　New York, August, 1914　No. 8

PUBLISHED MONTHLY BY THE
McGraw Publishing Company, Inc.
James H. McGraw, President.
C. E. Whittlesey, Secretary.
John T. De Mott, Treasurer.
239 West 39th Street, New York.
Telephone Call, 4700 Bryant.
Cable Address, Metchem, New York.

Rocky Mountain Office........421 Boston Bldg., Denver, Colo.
Pacific Coast Office......502 Rialto Bldg., San Francisco, Cal.
Chicago Office..........................Old Colony Building
Philadelphia Office...............Real Estate Trust Building
London Office............Hastings House, Norfolk St., Strand

E. F. Roeber, Ph.D., Editor.
H. C. Parmelee, Western Editor.

J. M. Muir, Manager.

*Yearly subscription price for United States, Mexico and United States dependencies,* $2.00; *for all other countries,* $2.50. (*European exchange,* 10 *shillings,* 10 *marks,* 12.50 *francs.*)

Copyright, 1914, by the McGraw Publishing Company, Inc.

Entered as Second-Class Matter at the Post Office at New York, N. Y., under the Act of Congress, March 3, 1879.

New York, August, 1914

EDITORIAL:

The Atomic Weight of Lead.......... 487
Raw Material for Steel Production.......... 487
Arms and the Man.......... 488

READERS' VIEWS AND COMMENTS:

Igneous Concentration of Metallic Values of Mixed Sulphides. By F. L. Clerc.......... 490
Is There a Complex Ore Problem? By W. Motherwell and Ira F. Morell.......... 490
Heavy Mexican Oil as Fuel. By C. A. VomBaur.......... 491
The Western Metallurgical Field.......... 492
Iron and Steel Market.......... 493
Leipzig Meeting of the German Bunsen Society.......... 494
The Non-Ferrous Metal Market.......... 496
The Construction of the Blast Furnace Stack. By J. E. Johnson, Jr. .......... 197
Notes and Observations on Ore-Treatment at Cobalt, Ontario, Canada, II. By H. Parmelee.......... 507
The Late Walther Feld. By Fred. H. Wagner.......... 514
Niagara Falls Meeting of American Electrochemical Society.. 514
Salt Lake Meeting of American Institute of Mining Engineers. 514
Research Work in the Laboratory and Mill. By Warren F. Bleecker .......... 515
Electrolysis of Fused Materials Containing Zinc. By Chun Hao Wang .......... 523
The Determination of Phosphorus in Phosphor Bronze. By E. W. Hagmaier.......... 524
The Emissivity of Metals and Oxides. By G. K. Burgess and P. D. Foote.......... 525
Energy of Vaporization of Carbon. By Carl Hering.......... 526
Recent Chemical and Metallurgical Patents.......... 528
London Notes .......... 534
Synopsis of Recent Chemical and Metallurgical Literature .......... 535
A New Porous Mineral Filter Medium.......... 537
Dry Kilns for Timber Products.......... 538
Filter Press Work in Cane Sugar Factories.......... 539
Filter Press Laboratory.......... 540
Hydraulic Reducing Valve.......... 541
Personal .......... 542
Obituary .......... 542
Notes .......... 542
Digest of Eectrochemical U. S. Patents (Electroplating).. 543
Book Reviews .......... 544

## The Atomic Weight of Gold

At the recent Leipzig convention of the German Bunsen Society, Dr. Krey in his speech of welcome on behalf of the German Chemical Society made the characteristic remark that not so long ago the older generation of orthodox chemists used to look at physical chemistry with feelings very much like those with which we (or some of us) view the art works of futurists and cubists. It is true this sentiment has changed, but if orthodox chemists were present at the Leipzig meeting, we are sure they must have been shocked by the papers by Dr. K. Fajans and Dr. O. Hönigschmid, who spoke of an indefiniteness of atomic weights and backed it up by the example of lead. And now they have been confirmed by so eminent and conservative an authority as Prof. Theodore W. Richards, of Harvard, who together with Max E. Lembert has determined the equivalent weights of sixteen samples of lead chloride obtained from different sources. "The result is amazing. Evidently, then, the chemical equivalents of these different specimens are markedly different from one another." Lead of radioactive origin has a lower atomic weight than common lead. And yet all the different specimens are chemically identical according to the most refined Harvard methods (we apologize to every Harvard man for this tautology). They are even identical according to spectroscopic analysis. They only differ in radioactive properties, and—in atomic weights. But what does it prove? That atomic weights are no longer constants of nature? Hardly, but it suggests that in lead there may be some admixture of very remarkable properties. What is it? Here is a wonderful opportunity for experimental research.

## Raw Material for Steel Production

A striking feature of the statistics of steel production in the United States in 1913, just issued by the Bureau of Statistics of the Institute, is that they show an increase in the output of ingots and castings of only 49,571 tons, or one-sixth of one per cent, over the preceding year, whereas pig iron production increased 1,239,215 tons, or 4.2 per cent. It is impossible to account for this divergence by inferring that stocks of pig iron increased during 1913. Analysis indicates clearly that the divergence was largely due to there being a higher proportion of basic pig iron to basic open-hearth steel in 1913 than in 1912, and this fact suggests a very interesting trend. The production statistics are as follows:

| | 1912 | 1913 |
|---|---|---|
| Pig iron in gross tons.... | 29,726,937 | 30,966,152 |
| Steel ingots and castings.. | 31,251,303 | 31,300,874 |

The production of foundry and mill grades, including foundry, malleable and forge iron, etc., increased from 6,423,312 tons to 6,605,366 tons, or 182,024 tons, 2.8 per cent, quite in keeping with the increase in pig iron as a whole. The production of Bessemer and low-phosphorus iron decreased from 11,664,015 tons to 11,593,385 tons, or 70,630 tons, while the production of Bessemer and acid open-hearth steel, almost the sole outlet for Bessemer and low-phosphorus pig iron, decreased from 11,467,122 tons to 10,801,011 tons, or 666,111 tons. The excess of pig iron over steel in 1913 was 7.3 per cent, which is only a trifle above the average; the excess in 1912, on the other hand, was below the normal, being only 1.7 per cent. It will be recognized that these percentages do not represent the loss in converting Bessemer pig iron into Bessemer steel ingots. There are other factors, the consumption of Bessemer pig iron in foundry operations, which is, however, quite limited, and, on the other hand, the use of scrap in acid open-hearth steel practice.

Comparing the production of basic pig iron with the production of basic open-hearth steel ingots and castings shows that in 1912 the proportion of pig iron to steel was a trifle over 58 per cent, while in 1913 it was nearly 62 per cent. This proportion is always suggestive of the quantity of scrap, chiefly new scrap, used in the basic open-hearth furnace in conjunction with pig iron, and we give below the proportions for each year since the statistics were first gathered. The statement begins with 1896, when the output was only 336,403 tons of basic pig iron and 776,256 tons of basic open-hearth steel, and ends with 1913, when the output was 12,536,693 tons of basic pig iron and 20,344,626 tons of basic open-hearth steel.

PROPORTIONS OF BASIC PIG IRON TO BASIC OPEN-HEARTH STEEL INGOTS AND CASTINGS, PER CENT

| | | | |
|---|---|---|---|
| 1896, | 43.3 | 1905, | 52.5 |
| 1897, | 52.7 | 1906, | 52.0 |
| 1898, | 50.1 | 1907, | 52.4 |
| 1899, | 47.4 | 1908, | 57.1 |
| 1900, | 42.1 | 1909, | 61.5 |
| 1901, | 40.0 | 1910, | 59.5 |
| 1902, | 45.2 | 1911, | 58.0 |
| 1903, | 43.0 | 1912, | 58.1 |
| 1904, | 48.5 | 1913, | 61.6 |

Minor variations in the percentage from one year to another may possibly be due to fluctuations in the volume of stocks, but these stocks are never particularly large, and the table shows conclusively a definite and important trend. In the earliest years the industry had not found its gait, and although there was doubtless much scrap available the largest proportion was not used. The maximum employment of scrap appears to have been in 1901, when the pig iron production was only 40 per cent of the steel production. For four years ending with 1903 the proportion of pig iron averaged 42.6 per cent, the proportion rising rapidly thereafter until 61.5 per cent was reached in 1909, and then with slightly lower percentages for three years a new high point of 61.6 per cent was reached in 1913.

The decrease in the relative consumption of scrap is not to be attributed to a failure in the supply of old material. Doubtless the outcome of old material increases from year to year, with more or less reference to the fact that ten, fifteen or twenty years ago, whenever it was that the present old material was new material, just put into use, the production and consumption of steel was increasing at a rapid rate.

Old material, however, does not furnish the chief supply of scrap for the open-hearth steel furnace, for the production of new scrap, including casting pit scrap, scrap produced by cropping in rolling, the shearing of plates and the fabrication of various steel mill products into final form, is much larger than the outcome of old material. The Bessemer steel process does not use its own scrap, and has not done so to any extent since the advent of the basic open-hearth furnace. The Bessemer steel industry, however, is decadent.

It does not follow that there has been in all plants an equal decrease in the proportion of scrap charged. The proportions have for years varied widely in different classes of plants. Those which use the least scrap, scarcely any, are, of course, the duplex works, partially treating the molten iron in the converter and finishing it in the basic open-hearth furnace. Statistics of dupex steel are available only for 1912 and 1913, the production being respectively 1,438,654 tons and 2,210,718 tons. Assuming for the computation that these duplex works used an equal tonnage of basic pig iron, it develops that the remainder of the industry used 54.8 per cent of pig iron in 1912 and 56.9 per cent in 1913. If one were able to segregate further and allow for the operation of Talbot furnaces, the proportion of pig iron would be found to be further reduced, but there is little doubt that the figures would show an increase in 1913 over 1912.

It is easy to foresee that as the industry grows in future and the basic open-hearth preponderates still more greatly over the Bessemer there will be a continued increase in the use of what may be called the non-scrap processes, and an increase in the proportion of pig iron used at the works which practice the regular pig and scrap process. The day of the blast furnace is not over, and it is even a question whether there is to-day sufficient blast furnace capacity at steel works to supply pig iron for full operation of the basic open-hearth capacity, increased as it has been so largely in the past few years.

### Arms and the Man

The past is effete and from us. The present is here and of us. The future is to come and for us. The past is valuable only as it teaches. The present is valuable only as we act. The future is good in that we can see. The three simple words, see, think, and act are part of a man's character, and how well one "sees, thinks and acts" distinguishes a man from a "mutt." Now coming from the past we find the adjectives noble, knightly, chivalrous that today possess the connotation of romance and give a glorious sheen to our thoughts. There is little of much greater value, nothing much more soul-satisfying, than the glory that comes from the day when knighthood was in flower.

How did these words acquire so much of beauty and of poetry and of spiritual grace, and how did knights rise to an honorable position? How did Chevalier Bayard "sans peur et sans rapproche" reach the ideal position? The reason we think can be found in progress of metallurgy and the reactance of metallurgy on esthetic and moral values is seen once again.

Brushing aside all verbiage and proceeding directly to our theme, we find that the man from prehistoric cave-man, seen incarnate today in a literary fashion in Jack London, has ever tried to get perfect weapons of offense and defense. This procedure was started in history by an eminent metallurgist bearing initials T. C. and went along under sign of the Hephaistos to the days of Colt, Krupp, and Maxim. It was by metallurgical reactions and by metallurgical endeavor that the suit of mail of Milan and the Toledo blade became perfect till at last even the feet were covered with protectors called "sollerets."

The perfection of armor was attained in the 15th century and was of such a degree that the shield was discarded as useless and the armored knight who was strong to mount his horse and move his muscles could not be wounded at all. The process was a gradual evolution, and had, long before that time in 1000 A.D. reached a temporary ultimate as is marked by the Battle of Hastings, where Norman knights conquered the Saxon warriors because they were better armed. Probably for six or seven centuries the man who had armor and was strong enough to carry it successfully was the first-class fighting man who dominated things so far as his power could carry. Finally, in the Battle of Crecy, which marked the introduction of gunpowder as a practical military agent, the kibosh was put on the knights and a new order of social affairs was started.

Let us analyze carefully these social changes—we had almost said economic changes, but all we had described happened before the days of Adam Smith. In feudal times a suit of armor was a valuable possession and constituted capital for its owner. But it weighed as much as 150 pounds and there were only a few men who were strong enough to carry such a weight and fight effectively. It was the exceptionally robust and tough man who became a knight. But provided he reached such a point in physical stamina that he could carry the armor and have surplus strength to use in offense, he was invincible against the man who did not possess armor or was not strong enough to fight in it. Given a man who reached a certain point in his physical make-up, he became all powerful. Below that point a man was defenseless because he was too slow.

For the men of the lower degree of fighting quality the only safety was in flight, and once caught whence he could not flee, he was lost and became a social by-product.

Such is in crude and bold outline the "Ursache" of knighthood. The knight was the exceptional man who was strong enough to carry armor and who, therefore, became militarily far stronger. A knight in armor could defeat in open fight, "ceteris paribus," 30 other men without armor.

Now with such objective conditions we might surmise that subjective conditions would be bad, that cruelty would be synonymous with bravery, that bad faith and treachery would constitute success, and that the weak would be pillaged by the strong to extermination. It would seem that the wolf and the shark would have assumed human form by a practical form of transmigration of souls.

What actually happened was quite the reverse. While injustice and rapine did exist, they decreased rather than increased. Loyalty, fealty, honor and self-sacrifice were in the knights' code given as the ultimate spiritual values. Women were placed in an idealized state and the flavor of chivalry pervaded life. The strong protected the weak and the weak repaid the strong by faithful service. In short, the power of association prevailed over the power of dissociation in a period when the "a priori" philosopher would have said that it was a question of how long before the "dog-eat-dog" method would have exterminated mankind. But while there was much of badness, badness did not increase, but rather goodness. Humanity energized joyfully in the days of old when knights were bold and ladies were fair. This is seen in the beautiful legends and stories of Arthur and the Troubadors. The novels of Scott and Dumas are true to the life of the feudal times. It was undeniably a time when moral values and spiritual values grew in beauty and strength.

With such cogitations and with such reflections in mind, we are struck with a certain analogy that today obtains in the world. The weapons that metallurgical science has forged today are commercial weapons of offense and defense, new processes to fight with, new thoughts to think with—science to materialize and to practicalize. But these weapons are so heavy that only the exceptional man can wield them. The thoughts of modern science are of commercial value, but it needs a thinker to absorb them. Those of lesser mentality who try, fail because of the nervous worry induced. Their powers are not strong enough and so they must sink to a subordinate position just as many men, weak muscularly, became in olden times archers, esquires or men-at-arms. We can see evidences of the inception of a process similar to the process that developed feudalism and chivalry. It may be undemocratic to foresee a triumph of aristocracy, but the future aristocracy will be founded on spiritual values and so an enduring one. The efficient man is vastly more efficient to-day because he uses his senses and thoughts in a transcendental manner for practical purposes.

We may be bold to predict from the foregoing that out of the present chaos that calls itself democracy a system will arise in which faithfulness, honor, loyalty and truth will be the goals, that the strong will protect the weak, that things will synergize and harmonize, so that the power of darkness will be overcome. Such a conclusion seems as comforting as it is irresistible.

# Readers' Views and Comments

## Igneous Concentration of Metallic Values from Mixed Sulphides

*To the Editor of Metallurgical & Chemical Engineering:*

Sir:—It is not easy to find an excuse for arithmetical errors such as occur in my paper on Igneous Concentration of Metallic Values from Mixed Sulphides, published in your journal, May, 1914, page 307. When such errors are found, the most fitting apology is a correction. Will you help me apologize to your readers by printing the corrected tables?

TABLE I

| COMBINED WITH | | GIVES | AND EVOLVES |
|---|---|---|---|
| One Lb. of | Lb. of | Lb. of | B.T.U. |
| Zinc | Oxygen<br>0.246 | $ZnO$<br>1.246 | 2,349 |
| Iron | Oxygen<br>0.286 | $FeO$<br>1.286 | 2,111 |
| Copper | Oxygen<br>0.252 | $Cu_2O$<br>1.252 | 1,067 |
| Copper | Oxygen<br>0.126 | $CuO$<br>1 126 | 6,197 |
| Carbon | Oxygen<br>1.333 | $CO$<br>2.333 | 4,374 |
| Carbon | Oxygen<br>2 667 | $CO_2$<br>3 667 | 14,580 |
| Hydrogen | Oxygen<br>8.000 | $H_2O$<br>9.000 | 52,254 |
| Sulphur | Oxygen<br>1.000 | $SO_2$<br>2 000 | 3,895 |
| Oxygen | $Zn$<br>4 062 | $ZnO$<br>5.062 | 9,540 |
| Oxygen | $Fe$<br>3.500 | $FeO$<br>4.500 | 7,391 |
| Oxygen | $Cu$<br>3.975 | $CuO$<br>4 975 | 4,041 |
| Oxygen | $Cu$<br>7.950 | $Cu_2O$<br>8.950 | 4,929 |
| Oxygen | $C$<br>0.750 | $CO$<br>1 750 | 3,280 |
| Oxygen | $C$<br>0 375 | $CO_2$<br>1.375 | 5,464 |
| Oxygen | $S$<br>1 | $SO_2$<br>2 000 | 3,895 |
| Oxygen | $H$<br>0 125 | $H_2O$<br>1.125 | 6,532 |
| Iron | $S$<br>0.554 | $FeS$<br>1 554 | 771 |
| Zinc | $S$<br>0 492 | $ZnS$<br>1.492 | 1,191 |
| Copper | $S$<br>0 503 | $CuS$<br>1.503 | 286 |
| Sulphur | $Zn$<br>2.031 | $ZnS$<br>3 031 | 2,419 |
| Sulphur | $Fe$<br>1 750 | $FeS$<br>2 750 | 1,350 |
| Sulphur | $Cu$<br>1 988 | $CuS$<br>2 988 | 569 |
| Sulphur | $Cu$<br>3 975 | $Cu_2S$<br>4 975 | 1,142 |

TABLE II

| COMBINED WITH | | GIVES | AND EVOLVES | ALSO GIVES | EVOLVES | TOTAL | ABSORBS | NET |
|---|---|---|---|---|---|---|---|---|
| One Lb. of | Lb. of | Lb. of | B.T.U. | Lb. of | B.T.U. | B.T.U. | B.T.U. | B.T.U. |
| $ZnS$ | $O$<br>0 495 | $ZnO$<br>0 835 | 1574 | $SO_2$<br>0 66 | 1285 | 2859 | 798 | 2061 |
| $FeS$ | $O$<br>0 650 | $FeO$<br>0 818 | 1342 | $SO_2$<br>0 728 | 1118 | 2761 | 491 | 2270 |

To burn completely 1 lb. $ZnS$, requires 0.495 lb. of oxygen for zinc and sulphur, and develops 2061 B.T.U. of available heat.

To burn completely 1 lb. $FeS$, requires 0.650 lb. of oxygen for iron and sulphur, and develops 2270 B.T.U. of available heat.

To burn 1 lb. of carbon to $CO_2$ requires 2.667 lb. of oxygen and develops 14,580 B.T.U. of available heat.

To burn 1 lb. of carbon to $CO$ requires 1.334 lb. of oxygen and develops 4374 B.T.U. of available heat.

It then requires about 7 lb. of $ZnS$ to replace 1 lb. of pure carbon burnt to $CO_2$, but only about 2 1-8 lb. if burnt to $CO$.

Heat developed per lb. of oxygen for $ZnS$ is $\frac{2061}{0.495} = 4164$ B.T.U.

Heat developed per lb. of oxygen for $FeS$ is $\frac{2270}{0.650} = 3492$ B.T.U.

Heat developed per lb. of oxygen for $C$ to $CO_2$ is $\frac{14,580}{2.667} = 5467$ B.T.U.

Heat developed per lb. of oxygen for $C$ to $CO$ is $\frac{4374}{1.331} = 3280$ B.T.U.

In a certain sense these errors are not important, as I was more concerned with the greater importance of utilizing as fully as possible the fuel values of various constituents of mixed sulphides, than with the publication of exact values in unfamiliar units.

The tables were compiled under conditions which prevented me from checking the results in the customary way.

F. L. CLERC.

Estes Park, Col.

## Is There a Complex Ore Problem?

*To the Editor of Metallurgical and Chemical Engineering:*

Sir:—On reading Mr. Lewis B. Skinners' contribution to the discussion on the above subject in your June issue, I was much surprised to find the following statement: "In passing, as there are fads in metallurgical lines as well as in others, I might note that we are going through a stage when the whole fraternity is on the *qui vive* trying to make every ore amenable to treatment by some flotation process. In the case of one-mineral separation in the United States this process has proven an aid; but it is of no benefit in the case of ores of zinc, which are truly complex, although being advocated for such. I do not know of any complex ore in Colorado, for instance, that could possibly show any advantage under this treatment."

It may surprise Mr. Skinner to hear that no fewer than four flotation processes, viz.: Potter, Delprat, Minerals Separation, and DeBavery, were invented for the express purpose of treating complex zinc ore at Broken Hill, Australia, and that during the last ten years several million tons of zinc-lead-silver ore and tailings have been profitably treated by these processes. As I was employed in mills using these processes at Broken Hill eight years ago I know whereof I speak.

I would like to see some of that "complex ore in Colorado that could not possibly show any advantage under this treatment." It might be worth while to have some experiments made with it.

Enormous strides have lately been made in "selective flotation" at Broken Hill (apart from the Horwood process), about which nothing has been published, and about which little or nothing is known in this country.

I might mention that the Murex process (not strictly a flotation process) is treating very complex zinciferous slime at the State mines in Germany.

W. MOTHERWELL.

Humboldt, Arizona.

* * *

*To the Editor of Metallurgical & Chemical Engineering:*

Sir:—Having followed with great interest the discussion of the complex-ore problem in recent numbers of your magazine I feel impelled to add my mite by way of comment on a few points.

I. Is there a complex ore? Or, going for instruction to the English dictionary, is there an ore "composed of several parts or components; knit, woven or folded together; involved, complicated, intricate; an aggregation; a number of metals combined into one grain or crystal?" All agree that there is. The question in my mind is: Is there a single ore that is not complex?

Is there a complex-ore problem? For more than thirty years of practice, study and experiment in the treatment of refractory ores, mainly by concentration, I have faced that problem. It is ever with us here in Colorado. We are getting more light, helps—among which such discussions as this are valuable—improvements in methods and machines; yet the problem is still here, complex indeed, inasmuch as almost every individual ore body calls for a separate solution.

Not only are many ores complex, but they call for a complexity of conditions in their treatment. I have found minerals of five different specific gravities in one ore on one table.

2. A great improvement might be made by employing or educating skilled operators. We have too few operators who are students, working with heart and mind for the success of the mill rather than for tally time and pay day. How shall we get them? Where shall we make them? That is a problem also, or perhaps a different phase of the same problem of complex-ore treatment.

3. Undoubtedly there are many mines now idle which would pay under careful and skilful management. If we would systematize our mills better, cut out the idea of "foolproof" machinery and employ at a premium a few interested, skilled and studious men who will work not only for salary but for success; cut out the idea of a big tonnage as the first essential (especially where it is impossible to get it with existing capacity of mine and mill) and hold to the idea of closest saving of mineral values and economy in all lines, we should have less idle mines, less decaying mills, monuments of failure and loss.

4. As to the element of complexity in different ores, let us consider a body of tellurium, for example. Good concentration will recover a fair percentage of values. Some of the tellurium will float and may be recovered by a method of flotation. Other values are like clouds of smoke and here cyanide gets in its work, providing the ore is oxydized or amenable to cyanide treatment. Occasionally there are particles of free gold and to save this we must amalgamate, concentrate or blanket—perhaps all three. We find pure gold bound up in grains of quartz so fine that after passing through a screen 100 meshes fine they still defy cyanide to penetrate and find their value; yet here good concentration by use of slimers and carpets will do much. The use of the glass to detect the losses is very essential. Then in many telluride ores very fine sulphides carrying high values are bound up in apparent gangue, calling for fine grinding and pebble mills and possibly oil flotation. Have we not here a complex condition, a complexity of methods, a complex problem calling for skilful intelligent handling?

5. A lead-iron-zinc-sulphide ore is, of course, complex enough to start with. Where a good concentrator will make good smelting values and at the same time cut out a middling product of iron cubes containing some zinc and traces of lead too low to pay its way, a late cyanide process has extracted 87½ per cent of the values with a 2½ per cent solution. I believe it would work on electrostatic iron as well.

An iron and free milling ore contains grains of quartz whose value will sometimes exceed the value of the heads. These can be cut out by a good concentrator and reground, occasionally in small mills and continuously in large ones, with good results.

When we go into the milling of refractory ores with knowledge of the problem before us and with a definite aim and plan of procedure, when we throw prejudice aside, when we make careful preliminary tests before installation and follow the test lines, when we employ conscientious and capable engineers who know what is required and are as anxious for our success as for our money, when we pick out efficient men for operators and give them the support that Carnegie gave and Edison gives to his men, then we shall begin to solve the problem.

6. The use of the microscope seems to me indispensable in the concentrating mill. An operator who is interested in his work and a student should be the possessor of the best pocket glass to be had. It will keep him posted as to many things. With it he can determine how clean his tailing sands are from attached mineral, with it he can be sure of the product he is making. In fact, every mill foreman should have a glass, a buckboard, pan and screens at hand for occasional pan and grinding tests, to be followed by assays, that he may know just what he is doing. But the first duty is to save the mineral which is freed, and until those "higher up" are interested to correct faults in the primary work the man running his shift is not likely to bother much about results.

Many pages might be written on the questions outlined and facts stated as to actual practice which are unbelievable, but the subject has already been thoroughly and ably handled. Such inquiries and discussions are in the right line. We hope to have more. We are in need of an army of thinkers and students to work out the many sides of the problem.

Ira F. Monell.

Boulder, Colorado.

---

## Heavy Mexican Oil as Fuel

*To the Editor of Metallurgical & Chemical Engineering:*

Sir:—Mr. R. M. Chatterton's recent communication as set forth on your pages 364-5 of your June issue is most interesting and helpful to those making power for electrochemical purposes.

Concerning my comments before the American Electrochemical Society, etc., it is not the possibility of using oil engines to operate on heavy Mexican fuel oil that I brought forth, but rather that such is now the fact and has been for some years past. It is true that Diesel oil engines in Texas do not operate successfully on heavy Mexican oil 18 deg. Beaumé or less, and it is well known that to operate well the Diesel engine must utilize the higher-grade fuel oils. There is, however, an improvement on the Diesel oil engine which has all its advantages, namely, high economy, less attendance than a coal power plant, etc., and which is burning these heavy Huasteca oils containing as much as 60 per cent asphaltum, and doing it successfully. A 1000-kw plant of these heavy Mexican oil-burning engines is in operation.

Records taken from one of these plants and comparison with Mr. Chatterton's gas-power plant for the same load-factor, 0.73, are here recorded. The crude oil costing 2.68 cents per gallon.

*Cost per Kw-hr.*

| | Coal or oil fuel | Attendance | Supplies | Fixed charges | Total |
|---|---|---|---|---|---|
| Gas power plant.. | 0.34 | 0.266 | 0.0282 | 0.470 | 1.104 cents |
| Oil engine plant.. | 0.177 | 0.175 | 0.0282 | 0.355 | 0.733 " |

From the above it is evident that crude oil for fuel for the oil engine would cost 3.75 cents per gallon before it would equal the cost of the producer gas equivalent with coal at $3.50 a ton. As there is no producer, and no manual firing to be done, the labor is decreased by one-third. The supplies are about the same. Fixed charges are less, as the initial cost is lower, space occupied is less, and there is no producer to deteriorate. In fact, the engine and a tank of oil being practically the entire power plant. The oil engine referred to is the De La Vergne.

New York City.

C. H. Vom Baur.

## The Western Metallurgical Field

### Smelting Furnace for Cyanide Precipitate

In a paper presented at a recent meeting of the Columbia local section of the American Institute of Mining Engineers, held at the State College of Washington, Pullman, Washington, Mr. P. S. Anderson, of Baker, Oregon, submitted some notes on a smelting furnace for cyanide precipitate. He anticipated that the matter would be of interest to operators of small cyanide plants where the installation of more expensive tilting furnaces is not practical. The furnace is described as being well adapted to the Taverner lead-smelting process, which the author had used for many years with good results. The last furnace was in use nearly four years. It was built in a car body, dimensions 24 in. by 42 in., and the brick work had to be replaced about every twelve months. Mr. Anderson's notes briefly described the construction and operation. The furnace is charged with about 100 lb. of cyanide precipitate, litharge and flux, approximately 70 lb. damp precipitate being used. As this melts down, more is added until there is about 7 in. of molten material in the furnace. After stirring, and when the slag is fluid, the first tapping of slag is taken off if necessary; otherwise, scrap consisting of old cupels, speiss, etc., is added, and fusion completed. In tapping, about two-thirds of the slag is taken off in the mold, and the remainder of the charge is heated until the cupel, on testing with a rod, feels smooth. Then the entire remainder of the charge is poured into a mold. After cooling, slag and speiss are removed, and the lead bar is placed in the furnace for cupelation.

Although lead is allowed to go to waste, there is a compensating advantage in the fact that slag and bullion are cleaner. Very little gold is found in the flue-dust, although there is considerable silver. Samples give average results of 12.10 oz. gold and 1140 oz. silver per ton. Slags assay, on an average, two cents per pound in gold and silver. Gasoline consumption is about one gallon per 18 lb. of precipitate, including cupelation and resmelting.

### Oil-Fired Blast Furnace in Washington

An oil-fired blast furnace has been erected at the Copper King mine, Chewelah, Washington, by J. J. Anderson, patentee. A description of this type of furnace and some data on experimental operation were given in this journal, September, 1912, page 543. It is believed that this is the first furnace of the kind installed in the Northwest for smelting copper ore on a commercial scale. For some time experiments were made at Van Anda, Texada Island, British Columbia, under the metallurgical direction of Mr. Thomas Kiddie, formerly superintendent of the Northport Smelting & Refining Company's works at Northport, Washington. At his suggestion Mr. Anderson made improvements in the furnace, based on the experience gained in the trial demonstrations at Van Anda. Several runs were made, of a few days each.

The present installation at Chewelah is expected to be in continuous operation, and the results will be looked for with much interest. The capacity of the furnace is said to be about 100 tons per day. As the United Copper Company is reported to have more than 7000 tons of 5 per cent copper ore ready for smelting, there will be no lack of suitable material and the furnace will be given a fair trial.

### Motherlode Sheep Creek Mill, British Columbia

At a recent meeting of the Western branch of the Canadian Mining Institute, Mr. W. P. Alderson, general manager of the Motherlode Sheep Creek Mining Company, presented some notes on the operation of the company's mill, from which the following data are taken. The ore consists of partly oxidized quartz and quartzite and is treated by an oil-sliming cyanide process. The mill is equipped with 10 stamps and Merrill cyaniding apparatus. Power is generated by six Pelton wheels. The following figures have reference to a three-month period.

| | |
|---|---|
| Tons of ore milled | 8781 |
| Average value per day | $13.37 |
| Tons ore milled per day | 98.3 |
| Tons milled per stamp per day | 9.83 |
| Percentage of time run | 98.1 |
| Pebble consumption per ton ore milled, lb | 4.84 |
| Cost of pebbles per ton ore milled | $0.08 |
| Extraction by amalgamation, per cent | 72.1 |
| Total extraction, per cent | 97.1 |
| Precipitation: | |
| Tons solution precipitated | 14,957 |
| Tons solution precipitated per ton ore | 1.7 |
| Value solution, per ton | $1.97 |
| Tailing: | |
| Total value | $3,336.78 |
| Average value per ton | $0.38 |
| Chemical consumption per ton ore milled: | |
| Potassium cyanide, 98 per cent, lb | 1.84 |
| Lime | 2.17 |
| Zinc | 0.31 |
| Total cost of chemicals | $0.38 |
| Cost of milling, per ton: | |
| Labor | $0.515 |
| Supplies | 0.674 |
| Sundries | 0.212 |
| Total | 1.401 |

### Chlorination at Park City, Utah

Since publishing a description of the metallurgical work of the Mines Operating Company, Park City, Utah, in our issue for July, 1914, page 431, we have been advised that the process has been improved by the addition of a refining method that yields high-grade silver bullion from the base precipitate of silver, copper and lead. This is a step that is expected to add to the profit of treating low-grade ore containing several metals, and we are glad to record the reported shipment of about 20,000 ounces of silver of 975 fineness. Formerly all of the valuable metals were precipitated as a base sludge and sold without refining, but silver is now separated.

Another chlorination mill in the Park City district, which is expected to be in operation in August, is that of the Park City Milling Company. This is a custom mill which will treat ore from the American Flag and other near-by mines. The process is similar to that used at the mill mentioned above, and the success attained at that mill is encouraging to the promoters of the custom plant. The latter was remodeled from an old dry concentrating mill where the Grasselli Chemical Company produced zinc concentrates from the tailings of wet concentration.

### Dry Concentration and Flotation at Joplin

Coincident with the reported failure of dry concentration in the Joplin district comes the statement that the flotation process is to be given a thorough trial within the next few months. The mill of the Clifford Dry Concentrating Company was erected at Duenweg about a year ago, and was modeled along lines entirely foreign to ordinary local practice. Whether it was in the hands of incompetent operators or whether the process was wholly unsuited to the conditions, it is certain that the results were disastrous and little or no concentrates were ever produced. Flotation, however, is now in use in the Joplin district, and experimental work will be continued throughout the summer. Representatives of the state and national Bureau of Mines are said to be investigating the process, particularly in connection with a more perfect recovery of zinc.

The state of Missouri has made plans for the representation of its mining industry at the Panama-Pacific exposition in San Francisco next year. A sum of $6,000 has been appropriated for making a suitable display which will include model operations of drilling, mining and concentrating. The latter will be illustrated in a 25-ton plant. Lead and zinc smelting methods will be shown by means of models, photographs and finished products, and other operations related to mining and metallurgical industries will be displayed. The arrangement of the exhibit will be under the direction of Mr. Otto Ruhl.

### Aurora Consolidated Sold

As a result of competitive bidding on the part of a number of mining companies the property of the Aurora Consolidated Mines Company, of Aurora, Nev., has passed into the control of George Wingfield, president of the Goldfield Consolidated Mines Company. The consideration is reported to have been about $1,000,000. The Aurora property is one of the important mines of Nevada, and is located in a district that has a record of large production. In addition to the mine there is a 500-ton all-climing cyanide mill which is now in operation. The ore is said to have a gross average value of about $5 per ton in gold, and to yield a 92 per cent recovery by the process adopted. The vendors were Jesse Knight, of Provo, Utah, and his associates.

### Consolidated of Carnotite Companies

As a result of the organization of the Consolidated Ores Company in Salt Lake City, nearly all of the carnotite deposits in the state of Utah have passed into the control of that company. The interests thus united are those of David Taylor & Co., the Unarium Mining Company, and the Moab Rare Metals Company. Over 125 claims of carnotite-bearing ground pass into the control of the new organization. Up to the present time all ore taken from these claims has been sold in Europe, but it is now the intention of the company to investigate at once the methods of treatment for low-grade ores, which continuing to market the high-grade material abroad.

### Resumption of Smelting in Mexico

A matter of importance to the metallurgical industry is the reported resumption of smelting operations by the American Smelting & Refining Company at Chihuahua and other points in Mexico. It will be recalled that the company closed all of its plants in Mexico as a result of the revolutionary conditions and the consequent disturbance in transportation and other facilities for carrying on its business. Recently, however, the company has been ordering members of its technical staff to return to the smelting plants, and it is the intention to resume operations as rapidly as conditions will permit. The Chihuahua plant probably will be the first to be blown in, as it lies in northern territory and is less subject to disturbance. This will be followed by Monterey and Velardena, but the plant at Aguas Calientes may not be opened for some time.

### Company Reports

**The Buffalo Mines Co.**, Cobalt, Ontario, Canada, operates a concentrating mill for the treatment of low-grade silver ore. The sand tailing is stored awaiting the probable erection of a cyanide plant; the slime tailing is cyanided; and the concentrates from jigs and tables, and precipitate from cyanidation are treated by a special process of cyanide-amalgamation. From the report of the company for the annual period ended April 30, 1914, the following metallurgical data are taken. The average silver content of ore milled was 25.31 oz. per ton. The mill treated 77,616 tons and recovered 76.14 per cent by concentration. The cyanide annex handled 13,388 tons of slime tailing which contained an average of 10.13 oz. silver per ton, and made a recovery of 77.8 per cent. The cyanide-amalgamation plant and refinery treated 20 tons of high-grade ore taken directly from the mine, 301 tons of jig concentrate, 923 tons of table concentrate, 6157 lb. of metallics from the mill and 17,347 lb. of cyanide precipitate. The total production of refined bullion was 1,682,759 fine ounces silver. The price received for silver during the year averaged about 59.5 cents per ounce. The cost of producing silver was 35.7 cents per ounce. The cost of concentration based on handling 77,616 tons of ore, was $1.41. Cyaniding cost $4.03 per ton of dry slime cyanided, or $0.71 per ton of original ore.

---

## The Iron and Steel Market

July has not altogether kept pace with June in exhibiting an improvement in the iron and steel market, but the improved conditions of June have practically continued through July, and this itself indicates an improvement in fundamental conditions, for July is normally a very dull month and a decided recession in activity would ordinarily be expected.

The first definite improvement in the buying of steel since the movement which began late in December and played out in February, began about June 1. For several months preceding shipments of steel exceeded the current orders, until the supply of old orders was practically exhausted and late in May steel production fell to a rate of somewhat less than 60 per cent of capacity. In June and July shipments have been at about 65 per cent of capacity, July having perhaps a slight advantage over June, while the bookings of orders for prompt shipment fully supported this rate of production.

Of contracting for forward delivery there was relatively little in June, while in July there has been a very fair movement, chiefly in contracts for third quarter. In the case of agricultural implement steel bar tonnage there has been general contracting through the year, and in many instances for the first half of 1915 as well. The total implement tonnage, however, has been relatively small, as much contract business was carried over July 1, contracts for the preceding twelvemonth having been very poorly specified. To a limited extent the automobile trade has contracted in sheets and other steel products through the early months of 1915. In the case of all the contract business extending into 1915, and in the case of a considerable part of that closed only for third quarter, advanced prices have been secured over the level prevailing for prompt shipment.

The steel mills in western Pennsylvania and Ohio, finding themselves in moderately comfortable position as to the volume of prompt business on hand, and with a considerable volume of contract business at advanced prices, announced an advance of $1 a ton in bars, plates and shapes, about July 21, making the basis 1.15 cents, Pittsburgh. The Chicago district mills had been a trifle under the Pittsburgh basis, quoting an arbitrary of 15 cents per 100 lb. over the Pittsburgh basis instead of the full freight of 18 cents, and in that district there has been a slight tendency to advance prices proportionate to the Pittsburgh advance. The extreme Eastern mills have also shown a tendency to advance. More clearly than a month ago there is a zone market in steel products, the outlying districts not obtaining the full Pittsburgh price plus freight. The development of zone markets almost always occurs when demand is light and prices are now, the Pittsburgh basis being restored, as to practically all territory, when the market becomes active and strong. At this time, however, some doubt exists whether the Pittsburgh basis will ever come into full force again as to all products.

Effective July 20 the American Steel & Wire Company advanced wire products $1 a ton, to a basis of $1.55 for nails, independents promptly concurring. As usual, contracts had been booked with the large jobbers, providing for specifications to be filed within sixty days. The regular fall movement is about to begin, and if specifications upon old contracts are stimulated as expected, another advance will probably be made in the first half of August.

These advances represent the first sign of an upward tendency in steel prices since the beginning of February, and with a seasonable expansion in trade in August, coupled with good influences expected from the enormous crops in prospect the steel trade may be found not simply to have made a little turn for the better but to have entered upon a period of important improvement. Stocks are very low throughout the country and in such circumstances it usually requires only a definite start to be recorded in order to bring about a general buying movement.

### Pig Iron

The pig iron buying movement which started about June 1 did not attain the proportions which would ordinarily be expected. June was no more than a fair month for buying, while July has been relatively dull. Prices have been almost stationary, except for a decline of 25 cents in Southern iron. The technical position of the pig iron market is fairly good, with prices so near the cost of production that there can hardly be any further important declines, while production and consumption are about balanced. Prospects naturally are for an increase in consumption rather than a decrease after such a long period of liquidation, and the idle furnaces, as a rule, will have to be tempted by higher pig iron prices before they will go into blast. Three or four merchant furnaces in the Central West, however, have under consideration the taking of chances for an advance, and getting into blast for the purpose of piling iron. The market is quotable as follows: No. 2 foundry, f.o.b. Birmingham, $10 to $10.25; delivered Philadelphia, $14.25 to $14.50; f.o.b. furnace, Buffalo, $12.75 to $13; f.o.b. furnace, Chicago, $14; f.o.b. valley furnaces (90 cents higher delivered Pittsburgh) Bessemer, $14; basic, malleable and No. 2 foundry, $13; gray forge, $12.50 to $12.75.

### Steel

There has been a great deal of price adjusting on contracts for billets and sheet bars and very little in actual transactions. The market definitely weakened early in July, with freer offerings by steel mills and at reduced prices, but at the close of the month a slightly firmer tone is reported. The market is quotable at $19 for billets and $19.50 for sheet bars, f.o.b. maker's mill, Youngstown, and at $19.50 for billets and $20 for sheet bars, f.o.b. maker's mill, Pittsburgh. Rods are about $25, Pittsburgh.

### Finished Steel

Bars, plates, shapes and wire products are $1 a ton higher, as already indicated. Quotations are f.o.b. Pittsburgh, unless otherwise quoted, but in western and eastern territory the Pittsburgh basis is not fully observed.

Rails, standard sections, f.o.b. mill, except Colorado, 1.25c. for Bessemer, 1.34c. for open-hearth.

Plates, tank quality, 1.15c.

Shapes, 1.15c.

Steel bars and bands, 1.15c., base.

Iron bars, 1.25c., Pittsburgh; 1.17½c. to 1.20c., Philadelphia; 1.05c., Chicago.

Sheets, blue annealed, 10 gage, 1.35c.; black, 28 gage, 1.80c.; galvanized, 28 gage, 2.75c.; painted corrugated, 28 gage, 2.00c.; galvanized corrugated, 28 gage, 2.80c.

Steel pipe, ¾ in. to 3 in., 80 per cent off list.

Steel boiler tubes, 3½ in. to 4½ in., 72 per cent off list.

Wire nails, $1.55; smooth fence wire, 1.35c.; galvanized barb wire, 1.95c.

Standard railroad spikes, 1.40c., Pittsburgh; 1.50c., Chicago.

Structural rivets, 1.55c.; boiler rivets, 1.65c.

Cold-rolled shafting, 67 to 68 per cent off list.

Chain, ⅜-in. proof coil, 3.00c.

---

## The Iron and Steel Institute

The annual meeting of this institution was held on the 7th and 8th instant in London under the presidency of Mr. **Adolphe Greiner**, whose address dealt mainly with the by-products of steel manufacture.

With regard to coke ovens, he said, they now worked for something else than the silvery metallic looking coke of the Durham beehive ovens. The resulting gas was formerly employed almost entirely for heating the ovens, but on account of its richness it was more profitably employed for metallurgical purposes and for lighting. It might in future be used for the production of nitric acid and, possibly, also for the hydrocarbons from which it was expected the synthesis of artificial rubber would be effected.

He advocated the removal of dust from blast-furnace gases, and eulogized the work of Mr. B. H. Thwaite, who demonstrated the advantage of the direct use of those gases for the production of electrical energy. There was a considerable number of metallurgical works running between five and ten blowing engines and from ten to fifteen generators, some of them showing an aggregate output of over 30,000 hp, for which coke-oven gas, blast-furnace gas, or both, were utilized. Valuable economy, to the extent of 10 to 15 per cent results from using the heat of the exhaust gases for steam raising.

Besides the gases there were also slags which were already being used for making a kind of Portland cement, and also for bricks.

There was still much to be done in modern steel works in effecting economies by utilizing heat which was now lost. Engineers might some day solve the problem of avoiding the tremendous heat losses now incurrent in the converters; and heat losses by radiation from reheating furnaces and so on would repay their serious attention. Again many rolling mill steam engines—particularly in reversible mills—discharged into the atmosphere large volumes of steam which might be profitably utilized in low-pressure turbines.

If metallurgical works produced in regenerative ovens the whole of the coke required for the blast furnaces, and if the slag were used for making bricks and cement, and the waste gases were used for the production of motive power, he estimated that the resulting economy would amount to about 9s. 6d. per ton of pig iron, 11s. 2d. per ton of steel ingots, and 12s. 6d. per ton of rolled steel, and that without taking into consideration the sum yielded by the sale of basic slag.

---

**Montreal Meeting of American Chemical Society.**—The date of the Montreal meeting has been changed from Sept. 8-11 to Sept. 15-18, 1914 (Tuesday to Friday).

**Johnson Electric Zinc Plant.**—Johnson Electric Smelting, Inc., has contracted for power with the Mississippi River Power Company for a plant at Keokuk, Iowa, where the Johnson electric furnace for the smelting of complex zinc ores will be installed in commercial operation.

## Leipzig Meeting of the German Bunsen Society

The twenty-first general meeting of the German Bunsen Society for Applied Physical Chemistry was held in Leipzig from May 21 to 24. It was called to order in the morning of May 22 in the lecture hall of the International Exposition on Books and Graphics by the president of the Bunsen Society, Prof. M. LeBlanc. Speeches of welcome were made by Geheimrat Schmalz, of the Department of Education of Saxony; by Geheimrat O. Mayer, president of the University of Leipzig; by Dr. Dittrich, mayor of the city of Leipzig; by Dr. Volkmann, chairman of the board of directors of the International Exposition on Books and Graphics; by Geheimrat Weinstein, representing the Reichsanstalt and the Bureau for Testing Materials, and by Dr. Krey, who spoke for the German Chemical Society and the Association of German Electrical Engineers.

The Bunsen Medal was conferred on Prof. Walter Nernst, of Berlin, who being absent on a lecture tour in South America, had sent a paper on the application of his new thermodynamic principle to gases. This paper was read by Prof. von Wartenberg.

In the business meeting held on May 23 in the lecture hall of the Institute for Physical Chemistry of the University the new officers of the society were elected.

Prof. Hans Goldschmidt, of Essen-Ruhr, Germany, the distinguished inventor of the aluminothermic method, is the new president, his term running from July 1, 1914, to June 30, 1917. For the same period Prof. M. LeBlanc, of Leipzig, was elected vice-president. Geheimrat Dr. von Boettinger was re-elected treasurer.

HANS GOLDSCHMIDT,
PRESIDENT GERMAN BUNSEN SOCIETY.

Professor Goldschmidt, after expressing his thanks to the society, referred to the preponderance of scientists in the Bunsen Society. This is due to the difficulty which engineers have in presenting papers before the society. On one side they are exceedingly limited by commercial considerations in the extent to which they can discuss their work. On the other hand, they must avoid the appearance of speaking "pro domo," which means in this case "for their pocketbook." Nevertheless the presence of engineers in the meetings of the Bunsen Society and their mingling with the scientists is highly important; they can give and take. In recent years in both scientific and engineering circles in Germany there is felt a certain lack of able young assistants. In parenthesis Dr. Goldschmidt remarked that graduates of modern German woman universities have not the slightest difficulty in finding good positions in science as well as engineering, not for their looks but for their ability. But the demand for young able chemical assistants is now greater in Germany than the supply, and if this situation should continue it would mean a national calamity. In conclusion Dr. Goldschmidt referred to the work of Bunsen, who was a scientist but always sympathized with the work of the engineer. As many of his students have become engineers as scientists. The influence of the Bunsen Society should manifest itself in the same direction.

According to the report of the board of directors the number of members on April 1, 1914, was 792. The assets of the society amount to over $8,000.

The numerous papers presented at the meeting will all be published in full in the organ of the Bunsen Society, the *Zeitschrift für Elektrochemie*. Abstracts of the papers appeared in the issue of June 1, while publication of the papers in full has begun in the issues of June 15 and July 1 and is to be continued.

Dr. P. Klemm spoke on the application of the principles of physical chemistry to paper manufacturers, Dr. R. Rübencamp on printing colors, and Prof. E. Goldberg on engravings and special presses for engravings.

### Electroplating

An interesting review of the present status of electroplating was given by Dr. W. Pfanhauser, of Leipzig. He estimated that purely for electroplating work in Europe alone, 2,500,000 amperes are in use, and in the whole world 3,000,000 amperes. This corresponds to 15,000 tons metal deposited per year in electroplating (not including electrolytic refining). Thirty-five per cent of this work is done in Germany and Austria.

Besides nickel plating, zinc plating is now coming to the front. For zinc plating of wires, ribbons, and tubes, 300,000 amperes are now in use. The main interest of progressive electroplaters is at present directed toward improvements in mechanical appliances. But fundamental changes in the chemistry of electroplating may also come and the author thinks that the next chemical revolution will be the use of fused electrolytes.

### Indefiniteness of Atomic Weights

Two rather revolutionary scientific papers, both coming to the conclusion that the atomic weight of an element has not a definite value were presented by Dr. K. Fajans, of Karlsruhe, and by Prof. O. Hönigschmid, of Prag, respectively.

In his paper "on the final products of radio-active disintegration series" Dr. K. Fajans said that until recently it has been assumed that a chemical element has always the same atomic weight from whatever mineral it may have been isolated. But when a year ago the author and Soddy brought the radio-active elements in line with the periodic system, the hypothesis was suggested that there are elements which while entirely identical in chemical respects may differ in atomic weight up to eight units and which differ otherwise only by their radioactive properties (rays, speed of disintegration). This hypothesis was first based only on indirectly determined properties of radioactive elements of short life and it was therefore important to prove experimentally that two elements which appear to us to be identical chemically can have different atomic weights.

The author then concluded that this test could be made with lead. He considered it as probable that the atomic weight of lead formed in the course of millions of years in uranium minerals as the final product of the disintegration of uranium would be different from that of lead obtained from ordinary lead minerals.

This conclusion has been tested and has been fully confirmed by the author's former collaborator, M. Lembert, in the laboratory of Prof. Theo. W. Richards in Harvard.* Lead from uranium minerals was found to have the atomic weight 206.6, while ordinary lead has the atomic weight 207.1. The possible error is at most one or two units in the last decimal and is therefore much smaller than the difference found experimentally.

Of greatest interest is the fact that these two kinds of lead are not only chemically identical, but also identical in spectroscopic respect. On the basis of similar considerations it is probable that lead from thorium minerals has a higher atomic weight than ordinary lead. Possibly ordinary lead is but a mixture of lead from uranium and lead from thorium. The question comes up whether the atomic weights of most elements are perhaps only mean values of the atomic weights of several chemically identical elements which therefore cannot be separated by chemical means. Atomic weight researches have therefore to meet an entirely new problem; that is to investigate how the atomic weights of the elements depend on their origin.

The paper by Prof. O. Hönigschmid on a "revision of the atomic weight of uranium" gives the results of a determination by analysis of uranium bromide. His atomic weight of uranium is 238.18, that is 0.3 units below the present international value. He considers the value 226.4 for the atomic weight of radium to be improbable, since the difference between the atomic weights of uranium and radium must be at least 12, that is, 3 x 4 (atomic weight of helium). His own value Ra = 225.97 is therefore considered to be more probably correct.

At the same time the author determined, jointly with Stefanie Horovitz, the atomic weight of lead obtained from uranium ore and found 206.73, that is, 0.4 less than the atomic weight of lead obtained from ordinary lead ore free from uranium.

### Other Papers

Prof. E. Cohen, of Utrecht, spoke of the metastable state of metals. By dilatometric methods it has been found that the metals as we know them now are metastable and contain simultaneously several allotropic modifications. For this reason the metals are not in equilibrium at ordinary temperatures and gradually disintegrate. The author reported on new experiments in which he obtained by very sensitive electric methods the same results as by dilatometric measurements.

Prof. H. von Wartenberg, of Danzig, discussed the possibility of the existence of gaseous alloys; Prof. F. Fichter, of Basel, spoke on the Kolbe reaction with $HOOC{-}CH_2.SO_3H$; Prof. H. Goldschmidt, of Christiania, on the equilibrium between hydrogen ions, alcohol and water; Prof. A. Hantzsch, of Leipzig, on indicators; Profs. F. Haber and G. Just, of Berlin, on new experiments on the emission of electrons in chemical reactions; Prof. G. Bredig, of Karlsruhe, on the chemical kinetics of formic acid formation; Prof. H. Bechhold, of Frankfurt on Main, on the existence of colloidal solutions of sodium urate; Prof. R. Marc on the kinetics of adsorption; Prof. M. LeBlanc on the photobromination of toluol; Mr. N. S. Hatfield on some new electric apparatus (a hydrogen-electrode meter; a flame arc lamp with improved efficiency and diminished carbon consumption; a time switch without mechanism); Prof. O. Sackur on the equation of state of gases and the theory of quanta; Prof. W. Loeb on some fundamental chemical problems on the effect of high-tension electric currents on the growth of plants; Dr. G. Schulze, of Charlottenburg, on electrolytic valves; Prof. W. A. Roth, of Greifswald, on graphite, diamond and amorphous carbon; Dr. V. Falcke, of Leipzig, on the reaction between ferrous oxide and carbon and between ferric oxide and iron; Dr. A. Goldmann, of Leipzig, on the theory of the Becquerel effect; Dr. K. Schaefer, of Leipzig, on optical investigations of the constitution of inorganic acids, salts and ester; Dr. M. Volmer, of Leipzig, on photochemical sensitiveness and photo-electric conductivity; Dr. E. Wilke, of Heidelberg, on the Tyndall phenomenon, and Dr. M. Trantz, of Heidelberg, on two gas reactions.

Next year's meeting will be held in Karlsruhe, beginning May 13, 1915.

## The Non-Ferrous Metal Market

Beginning July 1 the non-ferrous metal market gave evidence of greater activity and firmer prices. This followed the marked depression during the latter part of June when prices fell off materially and sales were small. Copper and tin have benefited most by the change, while lead and spelter continue to remain quiet and fairly inactive.

**Copper.**—Prices for this metal advanced from the low figure of 13.20 @ 13.25 cents in the latter part of June to about 13.55 @ 13.65 early in July. The market stiffened and sales abroad were greatly increased, while local consumers also bought in larger quantities. Nevertheless stocks have increased, as shown by the report of the Copper Producers' Association for June.

**Tin.**—Favorable statistics on this metal published on the first of this month affected the market and added to the general tendency toward higher prices than prevailed in June. July tin is quoted at 32 cents in the domestic market.

**Lead.**—The New York market has remained firm but the Western market is somewhat lower in price and quiet. New York quotation is 3.90 cents, and St. Louis 3.72½ @ 3.75 cents.

**Spelter.**—Prices for this metal improved slightly from those of June, but the market is quiet and without feature. New York prices are 4.90 @ 4.95 cents, and St. Louis 4.75 @ 4.80.

**Other Metals.**—The market for aluminium is poor and sales are small. The metal is quoted at 17½ @ 18 cents per lb., New York. Business in antimony also is quiet, but prices are firm, ranging from 5.65 to 7.35 cents for various brands. Quicksilver is quoted at $37.50 @ to $38.50 for flasks of 75 lb., New York, and $37.50 at San Francisco.

**Specific gravity separation** applied to the analysis of explosives is treated in **Technical Paper 78** of the Bureau of Mines. The authors are C. G. Storm and A. L. Hyde.

**The Richards Pulsator Riffle** is an application of the Richards pulsator jib to riffles such as are used in hydraulic mining operations or on dredges for the recovery of gold. The ordinary Hungarian riffle consists of angle irons placed across a sluice or table at right angles to the flow of water and gravel. A section across the riffle appears like a series of inverted letters L. In cleaning up the accumulation of gold from the riffles, the angle irons are removed and the concentrate taken out by hand. By applying a pulsating current of water under these riffles, according to the principle of the Richards pulsator jig, an automatic riffle with continuous discharge is produced. This device has been tested by the manufacturers, the Denver Engineering Works Co., and found to give excellent results on placer sand and gravel.

---

*See also the paper by Theodore W. Richards and Max E. Lembert on "The Atomic Weight of Lead of Radioactive Origin," since published in the July issue of the *Journal* of the American Chemical Society (vol. 36, p. 1329).—Editor.

# The Construction of the Blast Furnace Stack*

By J. E. Johnson, Jr.

*(Concluded from page 460)*

### The Shaft or Inwall

Above the mantle only two styles of construction have been used in recent years. For many years nothing but plain fire brick from two to five feet in thickness was used from this point to the top of the furnace, but the tendency for the lining to be eaten away more extensively just above the top of the bosh than anywhere else, which had existed very generally for many years became worse with the general use of fine ores, and the lining troubles which they brought with them.

As the cooling plate construction had given a good account of itself in the bosh, furnace-men began to put rows of cooling plates above the mantles to prevent this action, and this practice is now quite generally followed. These were at first simply built in the brick work and the pipes to them were brought in through small holes cut in the shell for that purpose. This, of course, put these cooling plates entirely beyond the possibility of renewal, if they failed they were done with and must be shut off and were soon burnt up.

To meet this situation some furnace men have cut holes through the furnace shell large enough to permit the removal of the whole cooling plate exactly as is done on the bosh, but this cuts up the shell very badly and even when this provision is made it is a matter of much difficulty to remove these plates through such a great thickness of brick work. It is, therefore, doubtful whether the trouble and expense of making these plates removable is worth the small gain to be obtained by that means. It will be seen that in the case of the furnace shown by Fig. 4* the course was adopted of bringing the water pipes for these blocks out through the shell so as to give access to the several connections but without making any provision for the removal of the cooling plates.

In early days of cooling plates they were made of cast iron with coils of pipe cast in them, these in all cases being built solid in the brickwork, without any provision for removal. The pipes were first made in one continuous coil zigzagging back and forth through the cooling plate, but an improvement on this was subsequently introduced which consists in making each pass of the pipe through the block separate and bringing the ends of all the pipes out through the outside surface of the plate, and putting the connections which put them in series on these projecting ends. By this means if the inside pipe failed it could be cut out and the one back of it left in service. Similarly if this failed by the gradual burning back of the furnace it in turn could be cut out and so on back for as many passes as the pipe might make through the plate, this number generally being from three to five. This arrangement is shown in Fig. 7.

For the protection of the bosh, hollow bronze cooling plates which do not adhere very tightly to the brickwork and on the inner surface of which the iron and slag do not burn fast in great lumps, so as to prevent their removal, were a great improvement, because they could be replaced as often as they failed and inside of the furnace kept practically to the original lines for a long period of time.

On account of this superiority for service below the mantle, the bronze cooling plate has often been used above the mantle also, but after considerable experience with it I prefer the cast iron plate with pipes cast in, for that service, for two reasons.

First, these plates above the mantle being the highest of any of the water-cooled portions of the furnace they are the first to lose the water in case of any partial failure of the water supply which reduces its head. I have known of several cases where this happened without the complete failure of the water supply. This means that these cooling plates above the mantle will lose their water first, and if they do so the bronze-plates are bad for two reasons. First the melting point of the bronze is many hundred degrees below that of the cast iron plate and its mass is much smaller, the body of the plate being hollow, so that when the water on these plates has been lost, even though the furnace be stopped at once, the heat of the surrounding materials will cause the bronze to melt after a comparatively short period, which leaves a considerable cavity in the brick work into which the bricks from above are likely to settle, thus causing at least the possibility of a crack in the lining, even though the gas does not blow out through the burnt cooling plate itself.

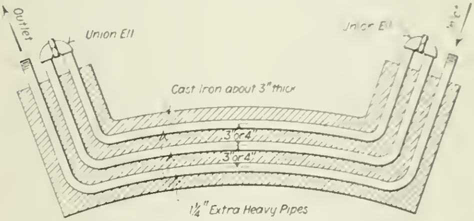


FIG. 7—CAST-IRON COOLING PLATE

With the cast iron plate, on the other hand, the conditions are quite different. The melting point of cast iron is not reached by the contents of the furnace at a point much above the mantle, so that these plates are much less likely to be melted out completely than the bronze plates, and even if the inner end next the stock is melted off the outer end is protected by the brickwork for a long time, if not indefinitely, and being practically solid except for the pipes cast through it a partial melting of the cooling plate does not form a cavity as in the case of the bronze plate.

Secondly, if even a small portion of the nose of the bronze plate be melted off it is destroyed completely, as this opens the water space into the furnace, but with the multiple pipe system several inches of the plate may be melted away and still, by using some of the outer passes of pipe, water may be put through it again, and its usefulness as a cooling member preserved indefinitely.

When these plates are installed, whatever kind may be used, provision must be made for obtaining access to them. In Fig. 4 two platforms for this purpose will be seen above the platform at the level of the mantle, these platforms being provided with a suitable handrail. This is important because in case of trouble with the circulation in these plates it is necessary to obtain access to them quickly in order to prevent their being burnt, and this cannot be done if ladders have to be arranged for the purpose. Moreover there is always a certain quantity of furnace gas stealing up the walls of the furnace, no matter how well it may be constructed, and while this may be so dilute that the workmen exposed to it will not realize the danger, he may nevertheless be made unconscious by it. Under such conditions, if working from a ladder he is almost certain to fall and be seriously injured or killed, whereas if a secure platform with a good handrail be provided he will fall upon this and can easily be rescued before further poisoning by the gas.

---

*Figures 1 to 6 were published in the instalment of the July issue.

The number of rows of cooling plates above the mantle is a matter of the individual conditions and the judgment of the operator. The customary number is probably from three to six rows, although in several cases these rows have been run all the way to the top of the furnace, spaced about as shown in Fig. 4. This is often done with furnaces intended to be run on ferro manganese or spiegel which are highly destructive of their linings. For ordinary furnace practice the consensus of opinion is that there is no advantage in having more than a limited number of rows of these plates.

There is a drawback to the use of these plates in that while they prevent the lines of the furnace from cutting back at the plate they do not prevent heavy erosion in the space between the adjacent rows very much as shown for the bosh in dotted lines in Fig. 3 and the steps so formed offer a lodgment for scaffolds in the very region of the furnace where the stock is in its pastiest condition and therefore most likely to scaffold. Consequently these steps tend to promote scaffolds with all their disastrous consequences.

For this reason some operators prefer not to use cooling plates above the mantle at all, but to let the lining wear away and cool the shell externally with sprays if it becomes necessary. It is stated by Mr. H. A. Brassert in his paper on Modern American Blast Furnace Practice read before the American Iron and Steel Institute, May, 1914, that "cooling plates above the mantles have only survived where they are placed from 18 inches to 22 inches back of the face of the inwall and in this position they have not much effect in preserving the original lines."

This statement may not be universally true, but may be considered as absolute proof that cooling plates above the mantle are not a panacea for lining troubles but on the other hand are only to be used sparingly and with great discretion.

From this region at the base of the shaft to a point a few feet below the stock line conditions of the temperatures and abrasion are such that well made fire brick alone will withstand a long campaign, and consequently in the great bulk of modern practice nothing else is used.

### The Stock Line and the Top of the Furnace

In this region the influences of chemical activity and temperature are greatly reduced over what they are in the lower portions of the furnace, but the lining is exposed to another form of attack which has proven almost as difficult to resist as that in the hearth and bosh.

This is the abrasive action of the stock as it is dumped from the conical bell into the furnace. The charge of coke in a modern furnace is from six to twelve thousand pounds, and in the best modern practice this is an extremely hard dense coke. In practically all cases also the limestone is in the form of lumps; sometimes this is crushed to go through a three or four-inch ring, but in many cases lumps which would scarcely pass through an eight-inch ring are tolerated, such lumps weighing up to twenty pounds.

When the bell opens these slide off its steeply inclined surface and strike violently against the walls of the lining at the stock line. In some cases also a considerable portion of the ore consists of hard lumps, some forms of ore having not only a high specific gravity, but also a degree of hardness comparable to that of granite, though these conditions are not usual in most present practice. These materials with their hard and abrasive nature inpringing on the stock line at a rate varying from one to two thousand tons per day cannot fail to exercise a destructive effect upon any brick work used for the lining, and as a consequence many forms of metallic protection have been used for this portion of the furnace.

The earliest form of protection known to me was angles of cast iron, six inches square on the face, six by nine inches in the body, by one inch thick. These were laid in fire clay on top of a course of brick work, and another course of brick work six inches thick built on top of them, then another row of angles was inserted, and so on. This armour extended for some eight or nine feet vertically in the furnace from a point two or three feet above the stock line to one seven or eight feet below it.

These after many years' trial proved to be unsatisfactory. The ends of the plates would break off and the protection of that area would be lost, but more serious still, cast iron swells when repeatedly heated and cooled through certain temperature ranges, and these are ranges which exist at the top of many furnaces.

It is probable, moreover, that a graphitization of the carbon in these plates occurs in consequence of their long heating, and this also is accompanied by swelling which tends to disintegrate the structure of the angle. Moreover, this swelling took place unequally at different points around the circumference of the furnace and the top of the brickwork was not only pushed up to an objectionable extent by the action but also at some points more than at others.

At other times and plants steel mantles or circular shields slightly smaller than the brickwork were hung inside the furnace at the stock line, but these failed because while the temperature at that point is not normally high enough to affect the structure of wrought iron or steel, it is high enough to cause those materials to warp very extensively in course of time, and if these mantles warped at all they must go inward since the brickwork close outside them prevented them from warping outwards. Such irregular projections of portions of the mantle into the furnace utterly destroyed the regularity of the stock line upon which the proper filling of the furnace depends, and brought about the very conditions which the mantle was introduced to avoid.

Cast iron or steel rings built up of segments were tried at some plants. These were built into brick work practically like a course of iron or steel bricks at intervals of two or three feet vertically, but as the stock has a considerable outward velocity as it leaves the bell these did not prevent it from cutting into the brickwork between them, and they, therefore, failed to fulfil the purpose for which they were intended.

I have never used these myself and I do not know of any case where they have been continuously used by any one plant for a long series of years.

One of the earliest successful means of solving this troublesome problem was an adaptation of the old cast-iron angles, first made by the writer so far as known to him, in 1903 or 1904, at the plant of the Longdale Iron Company.

After realizing the uselessness of the cast-iron angles, the suspended mantles, and various other schemes, it seemed likely that wrought iron being much lower in carbon than the cast iron, would be free from the tendency to grow by repeated heating and cooling, and would have also the physical strength needed to prevent breaking off the vertical portions of the plates in service. It would also be free from the liability to extensive warpage which had destroyed the steel shields because the individual angles, six inches square on the face, would have between them spaces of an eighth of an inch or so at the closest, and these spaces providing room for individual expansion would prevent objectionable warpage which was the result of the cumulative expansion of a considerable area of the mantle as a whole.

Accordingly a trial of such angles was made. These were made of three-quarter-inch by six-inch wrought iron, six inches square on the face, six inches by nine on the portion built into the brick work, and were successful far beyond our highest expectations. Instead of being compelled to reline the top of the furnace at the end of every campaign as had previously been the case, a furnace would make two or three campaigns without disturbing the upper portion of the lining.

Since that time these angles have been used with some modifications at a considerable number of plants, and always, to the best of my knowledge, with entire satisfaction and success. Modifications have been made in some cases. The portion of the angles built into the brickwork has sometimes been made long enough to go entirely through the brickwork, and the outer end turned up into a hook, this being imbedded in concrete poured around the lining at the top of the furnace. I have never seen any tendency for these angles to work out of the brickwork which would necessitate this additional construction.

There is, however, a very simple method of preventing this, if such danger were anticipated by a simpler and less expensive means. The leg of the angles built into the brickwork can be sheared to approximately the taper which will make them lie to the circle of the furnace. If the sides of the plates before bending were sheared to an unbroken straight line this would result in slight gaps between the turned-down portions or faces of the angles, but this would be a matter of no importance and the portion of the angle built into the brickwork, having its largest end out, would be absolutely prevented from working forward into the furnace.

It is something of a nuisance to level up the outside courses of the brickwork so as to bring them level with the tops of these angles, when the latter do not run clear through the wall, and to avoid this difficulty bricks of different thickness may be used on the inner row where the angles are laid. By using what firebrick makers call the standard thickness of brick in the courses on which the angles are to come, and the three-inch thickness in the rear courses behind them, the thickness of a three-quarter-inch angle is just about compensated with a minimum of difficulty in levelling up and without using any but standard material.

There are no patents on the use of these angles made of wrought iron or mild steel though a patent on their use when made of hard steel is held by Mr. E. B. Cook.

Another type of metal protection for the top of the furnace is one designed by Messrs. Albert Broden, manager of the Reading Iron Company, and Frank C. Roberts of Philadelphia. This is shown by Fig. 8 and consists of a cast steel sleeve the shape and size of the furnace itself at the stock line, which rests on cast steel brackets securely riveted to the shell.

The downcomer opening is cast through this sleeve and all brickwork is left out between it and the shell of the furnace proper. Large openings are cut through the shell to render the sleeve accessible for expansion and to provide air cooling for it. Water troughs are cast in its outer surface and provision made for a spray pipe around the top so that a continual trickle of water may be kept up over its surface in case of necessity.

The bottom section is cast separately and is cooled by water pipes cast in. This projects down inside the top of the brick work and protects the upper edge of the latter from the abrasion of the stock. The cooling water is trapped from the pockets in the back of the brackets, which are fastened water-tight to the shell and so prevent any possibility of water getting down through the brickwork. The joint with the hopper at the top is made by a single layer of brick laid in the usual way. This is an excellent construction and has given good results since it was put into service a short time ago. The only objection to it is the expense, being made of steel castings with accurately machined joints at all points where the different portions come together, the construction is a very expensive one.

### The Shape of the Top of the Furnace

It was formerly customary to run the shell practically vertical to the top, putting brackets in the inside to support the hopper ring and other brackets on the outside to carry the wheelway for the filling barrows.

In early days the hopper ring was not even bolted down to the brackets but with the greater frequence of violent slips which followed immediately upon the introduction of large percentages of fine ore into the burden, it was soon found necessary to have a more substantial construction. This was begun by making the brackets of steel instead of cast iron and bolting the hopper and hopper ring to them. Finally Mr. Julian Kennedy pointed out the general weakness of this construction and the necessity of holding the top of the furnace down until the violence of the slip had passed by. In fact he claimed that by preventing the release of pressure at the top the violence of the slips could be much diminished, and he was the first to introduce the coned top shown in Fig. 2 in which the shell is drawn in to support the hopper ring directly, thus making a much better and tighter joint between the hopper and the shell and giving a construction of sufficient strength to resist all ordinary slips and explosions.

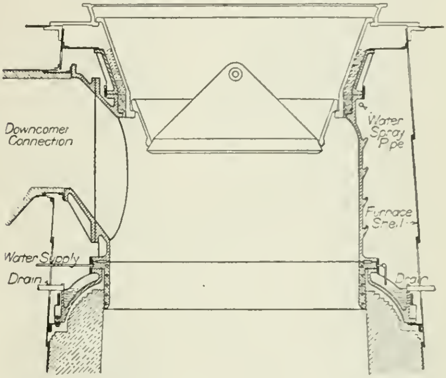


FIG. 8—BRODEN-ROBERTS STOCK LINE PROTECTION

The wheelway of the hand filled furnace is of course entirely eliminated as such, in modern mechanically filled furnaces, but an operating platform is provided, generally about as shown in Fig. 2.

The great mass of brickwork formerly put in above the bottom of the hopper is in fact perfectly worthless as it has no heat-resisting functions to perform and only serves to make a joint between the hopper and the furnace shell, and generally a very poor joint it was, having to be supplemented by clay packing, and accompanied by more or less leakage of gas, particularly during the blowing-in periods of the furnace when the gas is most deadly. The elimination of this construction has also resulted in putting the gas outlets further up toward the top of the furnace where they belong, somewhat as shown in Fig. 9 which is an elevation of the furnace shown in Fig. 2 and shows the location of the gas outlets more clearly.

### Thin-Lined Furnaces

It has been recognized for many years that fire brick exposed to the conditions in the blast furnace would wear back until the amount of heat carried off by their bases about equalled the amount brought in by their inside surface, after which time wear took place much more slowly. It has also been recognized that in the standard construction considerable life of lining can only be secured by a corresponding thickness, and that as this thickness wore away the departure of the furnace from its original and presumably correct lines became greater and greater, generally with more and more unsatisfactory working.

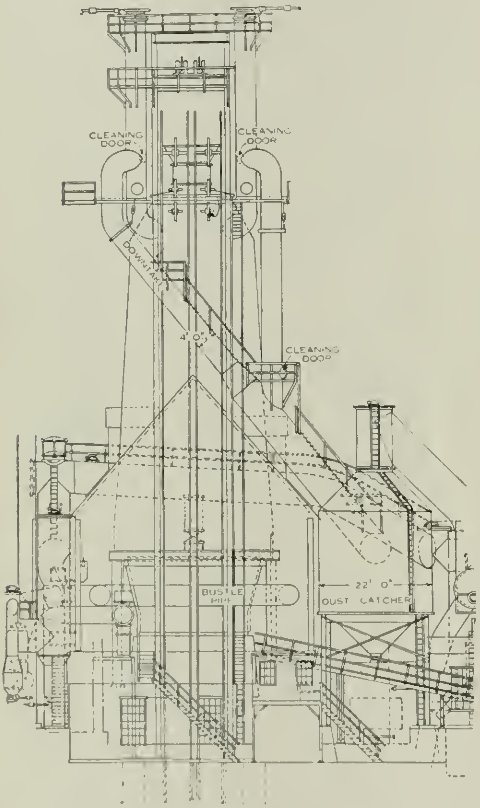


FIG. 9—ELEVATION OF BETHLEHEM STEEL COMPANY'S "A" FURNACE, SHOWING DOWN COMER

About fifteen years ago the experiment was tried in Germany with the idea of overcoming these difficulties of making the lining of the furnace exceedingly thin, only a few inches in fact, and cooling its exterior surface so as to maintain its original shape indefinitely. The idea has superficially much to recommend it, and after several years' trial in Germany it was introduced into this country, first at the Lucy Furnaces in Pittsburg, under the management of Mr. James Scott.

The German construction consisted of cast-iron staves with flanges on their exterior surface and jaws like flanges on the inside, into which the bricks were securely fastened. These were built up into a furnace shaft very much in the same way that the bosh jacket shown in Fig. 5 is built up, but the exterior was cooled by a water film or spray instead of the pipes cast in shown in Fig. 5.

The construction adopted at the Lucy Furnaces was different. There a steel shell was built much smaller in size in proportion to the lines of the furnace than the ordinary shell, since the thickness of the brick with which it was lined was only about one foot from top to bottom. On the outside of this shell were riveted annular troughs, each about two feet deep by six or eight inches radial width, and arranged so that water pumped into the top one flowed down through all the others in sequence to the bottom. In spite of great pains to secure absolutely air-tight construction, some water leaked into the furnace through the rivet holes and the results were unsatisfactory, though subsequently these difficulties were overcome.

Soon after this two thin-lined furnaces of this type were built at the Illinois Steel Works, and subsequently one of these was rebuilt with cast-steel plates instead of the boiler-plate shell and riveted buckets. This, however, did not prove satisfactory and the latter construction was restored. A bucket type of thin-lined furnace was also constructed at the plant of the American Steel & Wire Company in Cleveland.

A thin-lined furnace was subsequently built by the Detroit Iron and Steel Company according to the plans of their general manager, Mr. Max McMurray. This solved the problem of saving the original shell for supporting the top works of the furnace, which had not been done in any of the other constructions, columns having been run all the way up from the mantle to the top for this purpose.

In the case of the Detroit furnace the expedient was adopted of building a smaller shell with a thin lining inside the original shell and cutting a number of doors through to give access to the inner shell for examination, this shell being cooled directly by water sprays at the top forming a film of water which runs all the way to the bottom. The outside shell also presents the advantage of preventing the wind from blowing the water off the stack, thus leaving it dry on one side, and making a disagreeable spatter below, both very important points. This construction is shown by Fig. 10.

The Tennessee Coal & Iron Company have also had a thin-lined furnace in operation for a number of years. This was a very heavy boiler-plate shell with spray pipes arranged around the top. A series of galleries were arranged at different levels around this shell and outside these galleries was a sort of housing of steel slats to prevent spatter and to prevent the wind from blowing the water off the shell.

A different construction still has been used by Mr. Frank C. Roberts in a furnace built by him for the Warwick Iron Company, shown in vertical section in Fig. 11. In this the top of the furnace is supported by separate columns running up from the mantle, as previously described, and the shell is a boiler-plate shell, but instead of trusting somewhat to chance in the matter of the distribution of the cooling water around it, this is accomplished by a helical trough shown in larger section in Fig. 12.

The trough is supported by tap bolts which do not go all the way through the shell and, therefore, make leakage through it impossible. The bottom edge of the trough is spaced away from the shell by distance blocks as shown. Part of the water runs out the space at the bottom of the trough and that which cannot get out this way runs around the helical trough. In this way a perfect distribution of water is secured around the circumference of the shell and the danger of wind blowing the shell dry on one side is eliminated.

A compromise, one-half thin-lined and one-half standard construction has been in use for several years at the Port Henry Furnace of the Northern Iron Company. This construction shown in Fig. 13 is that of the former manager of the company, Mr. F. E. Backman, the design being carried out by Frank C. Roberts & Co. This furnace has a complete mantle shown in section resting on the vertical portion of the column at the level of the top of the bustle pipe. From this other columns run up on a slight inward batter to a second mantle some twenty-five feet higher. On this second mantle rests the upper portion of the inwall which is of standard construction. From this point down to the bosh there is a boiler-plate shell with rings of angles for supporting the brickwork riveted to its inside surface at intervals of five or six feet. This shell makes a joint on top of the cast-iron water-cooled segmental bosh jacket. The bosh jacket is lined with nine inches of brick and the nearly vertical portion of the shaft above it with thirteen inches.

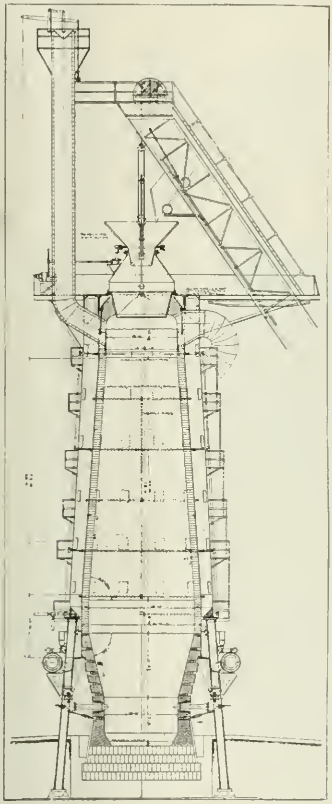


FIG. 10—DETROIT IRON & STEEL COMPANY'S THIN-LINED FURNACE

This construction is intended to prevent the gouging out of the lining above the top of the bosh which has been described above. This furnace has now been in operation for several years and is said to have given good satisfaction.

The conditions in regard to thin lining for the inwall or any point above the top of the bosh are vastly different from what they are below that point, because as already pointed out the convergent slope of the bosh provides a natural lodgment for the slag which runs down and chills upon its cooled surface in the normal operation of the furnace, so much so, that as before stated, if a furnace were started with an externally cooled bosh jacket entirely bare of bricks this would soon cover itself with a lining as good or better than the best fire brick which could be put upon it. But above the mantle the slope is in the other direction, the shaft of the furnace is a cone divergent downward, moreover except in its extreme lower portion there is no molten material, and if there were any it could not inpinge upon this outward flaring surface, and could

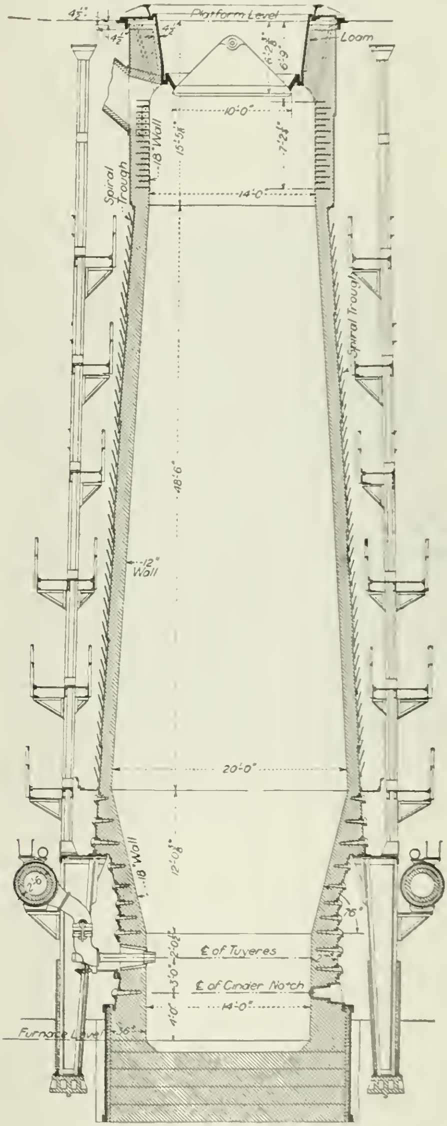


FIG. 11—SECTION OF WARWICK THIN-LINED FURNACE

not remain there if it did so. Therefore if the lining is once removed from this portion of the furnace it is gone for good and all, until restored by relining.

Moreover the furnace shell does not furnish much support in the vertical direction for any lining which may stand against it. It does prevent this lining from pushing out or falling backward, but it does not prevent its falling inward or sliding straight down in case of the failure of its support below. For this reason it seems to me necessary that the lining of the furnace above the bosh should consist of a sufficient thickness of brickwork to support itself and the portion of the lining above it. Systems of angle supports riveted to the inside of the shell may be used and may suffice amply to support the brickwork when it is built into the furnace, but these narrow ledges cannot in my judgment furnish the sound and substantial support which a body of brickwork two feet or more in thickness receives by resting upon a solid foundation like the mantle.

Moreover the thinness of the inwall seems to have an influence upon the work of the furnace altogether apart from its effect on the durability of the lining. Thin-lined furnaces have been found by their managers to be sensitive to the quantity and temperature of the cooling water circulated over the shell and in general to have troubles to which furnaces with linings of normal thickness are not liable, and some of the best furnace managers in the country who have tried them have told me that they had had enough and were perfectly satisfied in the future to return to the standard lining.

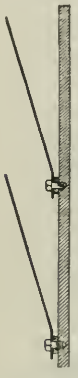


FIG. 12—SPIRAL TROUGH ON WARWICK THIN-LINED FURNACE

Some of the furnaces of the constructions here described are still in operation and some of them are said to be successful, but as a result of several years of experimentation no standard construction appears to have been developed which all advocates of this type of furnace are willing to adopt, and while the advantages of securing permanence of the lines of the furnace as constructed, of requiring for lining purposes only a small amount of brick, and therefore small expense and loss of time in relining, are undoubted, the essentially unsubstantial character of a wall only about a foot thick and 60 ft. or 70 ft. in height leaning inward at the top may well be questioned. Moreover, the thick lining has the advantage that within reasonable limits it gives the furnace some opportunity to cut itself out to the shape at which it will do the best work, so that minor errors of judgment in the original lines of the furnace as built may be corrected by the work of the furnace itself within the thickness of the standard lining, which is not possible with the thin one.

The lines of furnaces are not fixed like the laws of the Medes and Persians but shift with almost every campaign to meet changes of conditions or the changed views of their operators. With a lining of standard thickness and a standard shell large enough to contain it, such changes can within reason be made without affecting the shell, but with the thin-lined furnace this is not true. The shell must virtually have a shape exactly corresponding to that desired for the inside of the furnace and if it becomes necessary to change the latter this involves expensive and time-consuming changes in the shell.

For all these reasons, and for the far better one mentioned above, that in practice the thin-lined construction does not seem to have justified itself, it seems doubtful whether the development in this direction will be extensive or at least very rapid.

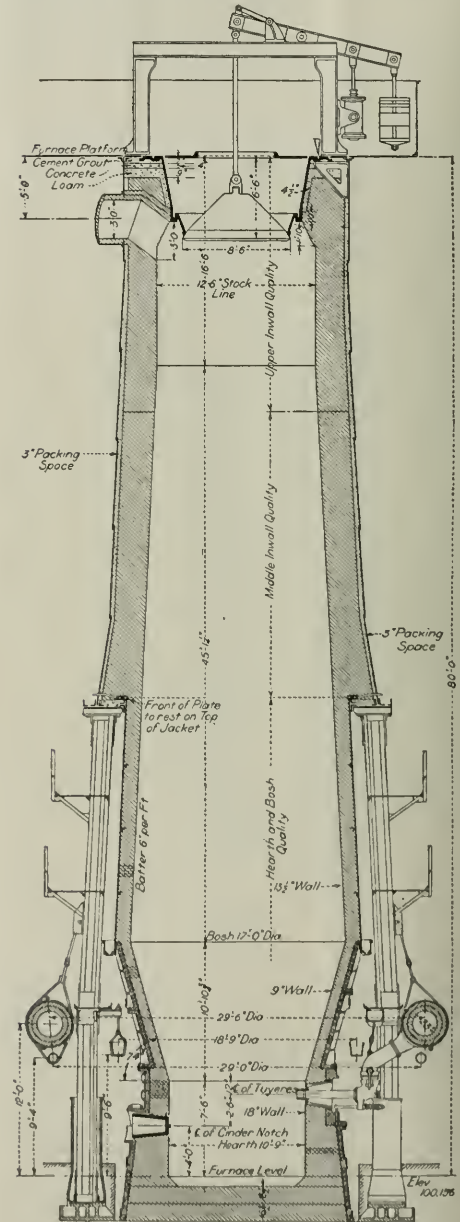


FIG. 13—SECTION OF NORTHERN IRON COMPANY'S PORT HENRY FURNACE

### The Ashland Construction

The construction shown by Figs. 1, 2 and 4 in which the mantle is supported directly upon the tops of the columns, numbering in modern practice from ten to twelve, has virtually been the standard ever since the adoption of the steel-shell construction, but is open to various objections from a practical and operating point of view.

These objections are that the columns come very close to the walls of the bosh and particularly to the outside of the hearth jacket, narrowing up the cooling ditch around the base of the latter and making the removal of any iron which may run into the ditch in a breakout extremely difficult, because this iron locks itself between the hearth jacket and the columns and in some cases can not be removed without blasting which would endanger the columns themselves. Moreover, when this construction is used the bustle pipe carrying the hot blast to the tuyeres has to pass outside the columns and the penstocks, carrying the hot blast from the bustle pipe to the individual tuyeres have to pass between the columns. These penstocks have to be swung out of the way whenever the tuyeres have to be changed, and the columns are greatly in the way at such times. There is nearly always a column close to the tuyere on one side or the other and access to the tuyeres is enormously hindered thereby. These columns interfere with the lead of the individual water pipes from the circular water main beneath the bustle pipe to the tuyeres and cooling plates and make it difficult to determine which cock controls which pipe, a matter of vital importance in case of a partial obstruction to the flow in one of these pipes, which then requires instant attention as the price of preventing the destruction of the cooling member which it supplies and the stopping of the furnace to replace the latter.

The writer having realized for years past the seriousness of these difficulties from an operating point of view when the charcoal furnace at Ashland, Wis., required reconstruction a few years ago, designed it along somewhat different lines, which are shown in Figs. 6 and 14. The central idea of the construction adopted is to remove the columns from their ordinary location immediately under the mantle and set them back far enough out of the way to give complete access to the base of the furnace and to prevent injury to the columns themselves in case of breakouts or other accidents around the furnace.

This was accomplished by building a square frame work of extremely heavy plate girders, the inside distance apart of which was slightly greater than the outside diameter of the shell of the furnace. These girders were supported on the top of the four columns to which they were riveted and strongly braced to prevent the possibility of failure by twisting. The shell was supported on these girders by eight brackets, two on each girder, these brackets being heavily riveted to the shell.

In order to prevent the sagging of the mantle plate eight cantilever brackets projected in under the mantle, one vertically under each of the main brackets. These were supported by a downward extension of the main angles which fastened the main brackets to the shell and the outer ends were held down by struts extending down from the ends of the main brackets.

The construction was a success in all respects and gave a degree of accessibility and convenience in operation around the bottom of the furnace beyond comparison greater than that of any other type. This accessibility is indicated by Fig. 14, which shows two men abreast, standing shoulder to shoulder inside the column, and outside the outermost point of the penstock. Of course, the tuyeres do not come in line with the columns in this construction any more than in the ordinary one.

For a furnace of this size no change in the design of the construction need be made. For a coke furnace of greater size and with greater liability to serious difficulties of operation, it would probably be desirable to use five columns, so that if one of them were to fail three of the girders, encircling more than one-half the furnace, would still stand and support it. This, of course, would only happen in case of a terrific disaster because the columns are set back so far from the furnace that no ordinary one could affect them, and on account of the abundant room around them they can be thoroughly protected by brick work.

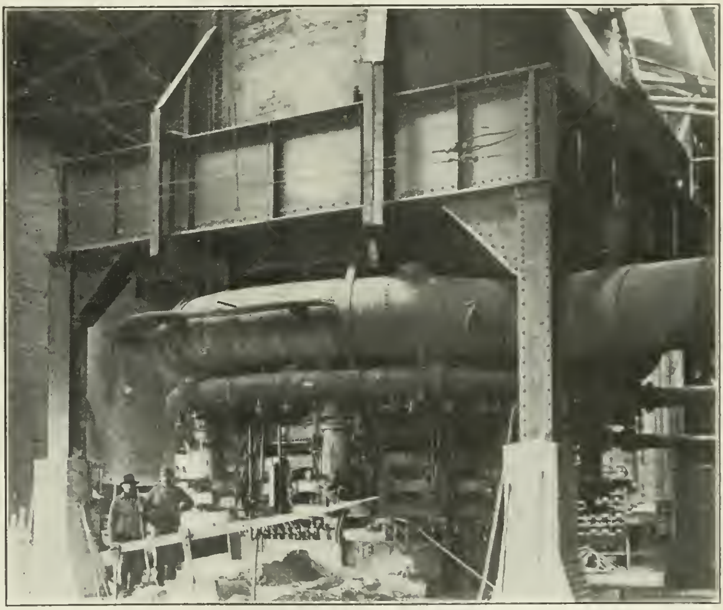


FIG. 14—ASHLAND CONSTRUCTION

In case this construction were used for a coke furnace a box girder would be used instead of the single plate girder and this box girder would be made watertight and serve for the circle pipe to supply cooling water around the furnace. This would prevent any possibility of the girders being softened or affected by heat no matter what happened.

This construction permits the bustle pipe to be put inside of the columns and thus to have the penstocks as close to the tuyeres as may be desirable without having any interference between the penstock and the columns. This also shortens up the bustle pipe materially, which reduces both its weight and its cost. One of the important features of this construction when used to replace the standard type is that the foundations, lying entirely outside those of the old construction may be put in while the latter is being torn out, and the structural work may be erected before the old furnace is down, as was done in the case illustrated, with the saving of many weeks in time, worth many thousand dollars more than the slight additional cost of construction.

### Firebrick

There is scarcely any feature of the construction and operation of the blast furnace of more importance than this and probably none concerning which less is known by the great majority of those to whom it is so important, the furnace managers.

The problem of firebrick has never been solved in terms of chemistry, or if so the solution is not known to furnacemen. This is probably because several other factors, such as the fineness of the grinding of the clay, and the method by which it is molded, the temperature and time during which the bricks have been burned, and other factors not reflected in their analysis have a vital influence on their character.

For this reason firebrick are to a great extent bought and sold on the basis of workmanship, freedom of the bricks from warpage, and general reputation. It is true that iron and alkalies in more than moderate amounts are barred because both unite with the silica at low temperatures and cause the fluxing of the brick under conditions far less severe than can be met with impunity by bricks free from these impurities. But further than this chemistry does not play a heavy rôle in the purchase or sale of firebrick.

It was customary a generation or more ago to use very large bricks, the size of 6 in. square on the small end, by 9 in. or 14 in. long was the standard in certain of the older iron-producing regions. But this was followed by a period in which a thickness of about 2½ in. became standard, virtually the same as that of red brick. These were made in lengths of 9 in. and 13½ in. so that two of one would equal three of the other. The straight, commonly known as the "square" brick, is 13½ in. long, 6 in. wide, or in the case of the tapered or circle brick, known as "keys," 6 in. wide at the larger end. Similarly the straight brick, 9 in. long is 4½ in. wide, and the "keys" 4½ in. wide at the large end.

These are relatively small bricks and require much labor for laying and involve a great number of joints, but it was claimed by some furnace men for many years that thicker bricks could not be burned satisfactorily, though I have seen years ago thousands of brick 6 in. thick which gave complete satisfaction in the furnaces in which they were used, which were small coke furnaces.

In very recent years firebrick manufacturers began to make furnace bricks 3 in. thick, and these are very much freer from warpage in the burning process than the thinner bricks as well as requiring less joints and less labor to lay them. They are, therefore, very much to be preferred from practically all points of view except that of cost.

In this respect the brickmakers have established certain customs which have not been permitted to any other trade. The standard price of bricks is based on the 9-in. by 4½-in. by 2¼-in. brick. Smaller bricks than the 9-in. are charged for at the same rate per brick as if they were the 9-in. size. This is explained by the brick maker on the ground that the clay in the brick amounts to very little but that the workmanship on it is just as much in the small brick as it is on the large one. The 13½-in. bricks, on the other hand, take a price of nearly 20 per cent higher than the 9-in. based on the same volume.

When he is asked why this is so the brick maker replies that they are more difficult to handle and to burn.

Similarly when it comes to the 3-in. lining instead of the standard thickness, the brick maker insists that he must have an increase of about 20 per cent in the price per unit of volume of these, although the warpage in this case is very much less, the labor decidedly less, and the burning but little more, apparently on the ground that he needs it, and he usually succeeds in getting it.

It is, however, no more than fair to the brick manufacturer to say that quality does not always receive the consideration from the furnace man that it should, and the manufacturer of a superior grade of brick is often forced to compete against a poor grade of brick on a piece basis, which is neither fair nor sensible, but is to a large extent the outcome of the difficulty in determining what real quality is, already described.

Firebrick are made in three qualities known respectively as "hearth and bosh," "inwall," and "top," intended for use in those regions of the furnace for which they are named, except that formerly the "hearth and bosh" quality was usually continued a number of feet above the top of the bosh, but in the best recent practice this quality stops at the top of the bosh.

These differences in quality are adapted to meet the difference in conditions in the different portions of the furnace. In the hearth and bosh there is little or no abrasion but intense temperature, and intense scouring action of slag and iron. To meet these conditions the bricks are made with a relatively large proportion of flint clay and a correspondingly smaller proportion of plastic clay. These bricks are not exposed to much abrasion and are therefore not particularly designed to resist, but through their composition and burning are made to stand extensively high temperatures successfully.

In the middle zone of the furnace in which the lining is known as the "inwall" the conditions of temperature and chemical action are considerably less severe, while those of abrasion due to the presence of some of the solid portions of the charge and the sand-blast action of its fine portions at the velocity imparted by the blast are considerable, and the cone in this portion of the furnace being convergent upward the sand blasting action is a factor to be reckoned with, whereas in the bosh with its divergent upward flare this is not the case. Inwall bricks, therefore, are made with more plastic and less flint clay than hearth and bosh brick to meet these conditions. At the same time they still have high heat resisting qualities.

At the top the conditions of abrasion are extreme, as has already been described, while the temperature in good practice in this zone of the furnace is generally below 1000 deg., so that the necessity of refractory character in the lining of this zone can be to a certain extent neglected, or at least need only receive an insignificant amount of attention as compared with what it demands in the lower zones. For this purpose the bricks are made with a large proportion of plastic clay pressed very hard, and burned to a great density, some of them resembling what is known as vitrified paving brick, almost as much as they do firebrick, and for the same purpose, resistance to abrasion.

Where no form of stock line protection is used such as those described above or an equivalent, the quality of the top brick is fully as important as that of the hearth and the bosh brick since top bricks which do not resist abrasion, permit the stock line to be gouged out by the drop of the stock from the bell, with the result that the correct distribution of the stock is made impossible and becomes largely haphazard, which is necessarily followed by extremely bad operation in the lower portion of the furnace, with the result of poor quality of iron, high fuel consumption, or of both. The necessity of repairing the stock line has for this reason been responsible for an appreciable percentage of all the cases in which blowing out for repairs have been necessary, though the fact may not have been apparent in all cases, because when a furnace which has been working well gradually begins working worse and worse, it is commonly and in general rightly assumed that the lining is too far gone to permit it to do further good work, and without any analysis as to the location of the wear which is responsible for the bad work, it is generally attributed to the inwall, although the top may be the part to blame.

It is unfortunate that more exact and accurate knowledge is not at hand on the subject of firebrick and their suitability for lining purposes, but the problem is so complicated that a complete analysis would be possible only after years of experience by an organization which contained both an experienced firebrick maker and experienced furnace men, a condition which has seldom if ever existed.

The firebrick manufacturer has, therefore, to adapt his product to the conditions described by the furnace man, and the furnace man has to use the brick furnished to him by the brick maker in the prayerful hope that they will give the results desired, but in the vast majority of cases without any better foundation for this hope than his confidence in a given brand of brick, and perhaps his belief that a certain brick maker understands the conditions well enough to provide him with a suitable lining.

It is greatly to be desired that the furnace man and brick manufacturer should meet directly rather than through their respective selling and purchasing agents. By discussing frankly and without prejudice their respective objects and difficulties progress would be made in real knowledge of this subject with resultant benefit to both.

I have already described the enormous change in the furnace conditions which began in the middle nineties. The greatly increased outputs and the vast increase in percentage of fine ore used in the burden, in combination with the introduction of mechanical charging brought about conditions under which the lining problem seemed to be almost insoluble. I know on the best authority that one of the largest brick makers was desperate at one time over the situation and would have been glad had he felt that he could afford to do so to surrender the furnace-lining portion of his business.

It seems extremely likely from the information which has been developed within recent years in connection with methods of charging, that these have been more responsible for unsatisfactory life of linings than was the poor quality of the linings themselves in many cases in which the firebrick manufacturer had to take the blame.

It has long been known that bad filling would rapidly destroy a lining by channeling, but certain types of mechanical charging which are theoretically correct produce conditions in practice under which it would be impossible for any lining to survive for any considerable length of time.

This matter really belongs under the subject of stock distribution and will be treated at greater length in an article on that subject.

### THE LAYING OF THE FIREBRICK

The mortar used for this purpose consists of ground fireclay which is mixed to grout of a consistency to suit the ideas of the furnace man or the boss bricklayer, and usually kept hot during the mixing and to a considerable extent even during laying, by a steam coil in the bottom of the clay box.

This grout or mortar is generally mixed quite thin, poured onto the brickwork with a large dipper and flushed into the joints of the brickwork, both from below by sliding the brick being laid up against the one just laid, so as to fill the joint as nearly as possible with fireclay, and then from above by filling in the space and working the fireclay down between the two bricks with a trowel if any opening sufficient for that purpose exists, which in general it should not do.

Many of the difficulties with linings have been attributed by some furnace men to bad bricklaying and particularly to wide joints. Some go so far as to insist that all unevenness must be removed from the bricks by chipping each individual brick where any appreciable amount of warpage exists, producing what is known as a case-knife job. This means that every joint shall be laid so close that it is impossible to get the point of a table knife into it.

Thick joints are undoubtedly very bad, but I have never seen any results produced by such extreme precautions which seem to me to justify the very greatly increased expense in laying the lining by this method. Careless work should on no account be tolerated, and if joints are found which are not thoroughly flushed the brickwork should be torn down and rebuilt properly. But as long as the firebricks themselves are made of clay suitably burnt, it has never been evident to me why the clay in the joints should not be burnt practically into the same structure as the brick itself, and in fact the brickwork which is torn out during the relining periods from the lower portion of the furnace where the heats have been high come out in blocks, the line of whose breakage frequently pays little or no attention to the original joints in the brickwork, proving to my mind that when properly laid, the fireclay joint becomes, by the action of the furnace itself, almost as good as the brickwork.

This statement is, of course, predicated on the assumption that fireclay of the same quality as the brick will be used. If inferior clay be substituted it may act as flux for the brick themselves and absolutely destroy the lining.

The practice of making the fireclay thin may easily, in my judgment, be overdone, for the reason that if the clay is very thin, when the bricks are settled to place with a mallet, if there is the least particle of warpage, the brick springs enough to throw the thin clay out of the joint and when it springs back to shape again this joint is practically open. When the fireclay is made so thick, on the other hand, that it will just about pour from the dipper, it is too plastic to permit this action and while the bricks may be driven up to a solid bearing with one another the slight joint which remains after they are in contact is fairly filled with fireclay.

### THE FILLING OF THE PACKING SPACE

In former times when furnace shells were built not much more than a quarter as strong as they are to-day they were frequently burst by the expansion of the brickwork within them and it was therefore universal practice at one time to provide a space of 3 in. to 6 in. between the outside of the brickwork and the inside of the shell which was filled with some yielding material to allow for the expansion of the brickwork, and yet continually resist it. In modern practice shells are so strong that they can resist the expansion of the brickwork and the latter is therefore laid up close to the shell and the small space necessary as a construction allowance is quite frequently grouted with concrete which, of course, is entirely unyielding. This means that the shell must be strong enough to resist the expansion of the brick or else it must stretch enough to accommodate the expansion of the brick within its elastic limit. Probably both these actions take place to some degree, but in any event this plan is not safe except with a shell of the strongest and best construction. If the brickwork were laid up tight inside a shell of older type the latter would probably be burst within a short time, as unfortunately has happened only too often even with the greatest precautions.

To prevent this it is customary with such shells to leave a space between shell and lining and fill it with some material which is yielding and yet to some extent resistant. The necessity of resistance arises because if an open space were left between the brickwork and the shell the internal pressure would push the brick back, break the bond, and ruin the keying, so that some bricks would be likely to fall out which would start a hole in the lining, and once started this would rapidly enlarge itself so as to destroy the lining. The bricks therefore must be held up to their work by some sort of filling between them and the shell.

Some furnace men prefer for this purpose clay, but clay is only slightly compressible, and I prefer pumice cinder, made by running a light slag onto wet ground, or into a tank of water. The steam formed by the heat of the slag puffs the latter up into a huge sponge whose total volume is many times the volume of the slag from which it is made. As it is crushed under pressure its volume becomes smaller and smaller by the progressive destruction of the cells, first of the larger and then of the smaller sizes, but the material maintains its resistance to compression almost constant throughout a very great diminution of volume.

These are the conditions which we have to meet, as brickwork, unless rigidly bound, does not expand elastically like steel, but when expanded retains its new size, never contracting, or never to anything like the degree to which it had previously expanded, so that as its temperature varies it undergoes a slow but constant growth. Thus a furnace shell may be amply large at the beginning of a campaign and for several months or a year, but gradually as the lining increases in size, when all the compressibility of the backing is gone, the direct expansionary force of the bricks is transmitted to the shell, and while the steel is stronger than the brickwork inch for inch, the latter is so much greater in area in any given section of the furnace that it generally bursts a thin shell when the "give" of the backing is gone.

In order to make the backing gas-tight the pumice cinder is sometimes mixed with clay, but this has the effect of reducing its compressibility especially as the clay is apt to burn hard after the furnace has been in operation for a while, and this therefore limits the amount of compression which a given portion of the backing can undergo without exerting undue stress upon the shell.

### DRYING THE LINING

Even with the best possible practice several tons of fireclay are used in laying the lining of a furnace, and this being mixed with something like an equal weight of water there is a great quantity of water in the lining when the brick laying is finished. This is capable of doing great damage and should therefore be removed by thoroughly drying the lining before the furnace is put into operation.

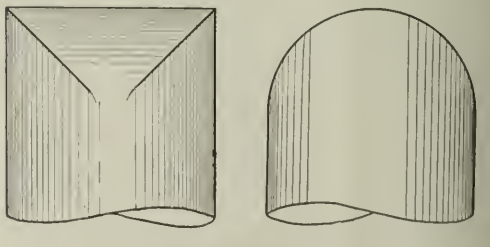
Various methods are in use for this but usually a temporary brick oven is built immediately in front of the tapping hole, and communicating with the furnace through it. The bell is closed and draft produced either by opening the bleeder or allowing the main draft stack to draw on the furance through a stove. A fire is built in the temporary oven and the gas from this passes into the furnace and warms it up, drawing out the moisture from the face of the brickwork first, and gradually as the heat works through drying out the whole mass quite completely.

The hot gas also acts as a carrier for the steam formed from the moisture and takes it out of the furnace. This drying-out process lasts anywhere from one to three weeks according to my judgment of the furnace manager and the state of the iron market.

There is no doubt that the operation is much better carried on slowly than rapidly, but a very moderate rate of firing will bring the warmth through a wall of 2 ft. or 3 ft. thickness in the course of three or four days, and a week of this treatment is in general sufficient to dry out the clay about as thoroughly as it can be done by this method. Of course, if the furnace is ready for operating before the rest of the plant it is well worth while to continue the fire for drying out for two or three weeks or even longer if convenient. But in my judgment three-fourths of all the benefits to be obtained by drying will be obtained in the first week of moderate but steady firing, day and night.

The removal of this moisture not only prevents the possibility that the rapid heating which would come from the actual operation of the furnace on a green lining would convert the moisture of the fireclay into steam so fast as to drive the clay out of the joints, and perhaps blow objectionable holes through the packing at the back, but it also exercises a very objectionable effect on the operation of the furnace while blowing in when it is already very cold by reason of the fact that its initial charge is not preheated in its descent, but necessarily cold clear to the bottom.

I have never had any experience with blowing in on a green lining, but I should expect that much more fuel would be required for the first two or three days of such blow in than would be required on a furnace with a thoroughly dried and warmed lining, and that the difficulty and delay in getting the furnace into normal operation fould be much greater.



CYLINDRICAL STOVE TOP

**Erratum.**—In our last issue, page 408, Fig. 35 of a cylindrical stove top was incorrect due to a mistake of the draftsman. It is now reproduced in correct form. In the early days many stoves were fitted with a cylindrical top as shown in this illustration and this shape conforms with the mechanical requirements that all sections of the stove shall be circular in order to resist deformation, but this style of top is difficult and expensive to fit and seems particularly liable to give out along the square corner where the horizontal cylindrical surface of the top meets the vertical surface of the stove body, and stoves are now almost universally fitted with either conical or spherical tops.

# Notes and Observations on Ore-Treatment at Cobalt, Ontario, Canada—II.

BY H. C. PARMELEE

### Concentration

In a preceding article[1] the writer pointed out the growing importance of concentration at Cobalt, and showed that by far the greater tonnage of ore mined is treated first by ore-dressing processes. The material thus treated is low-grade wall rock, containing from 15 to 30 oz. silver per ton. It is distinguished from the high-grade ore which occurs in narrow veins and contains from 2000 to 4000 oz., and even as high as 6000 oz., silver per ton. The value of the low-grade ore depends on the extent to which the vein walls are mineralized. As delivered to the mill it is enriched by the admixture of fine ore broken from the high-grade veins. Mill feed in the district will range from 20 to 35 oz. silver per ton.

By preliminary processes of hand-sorting, either underground or on picking-belts, and coarse crushing and jigging, the high-grade vein material is readily recovered. The wall rock, on the other hand, in which silver and its minerals are disseminated, requires fine crushing before concentration can commence.

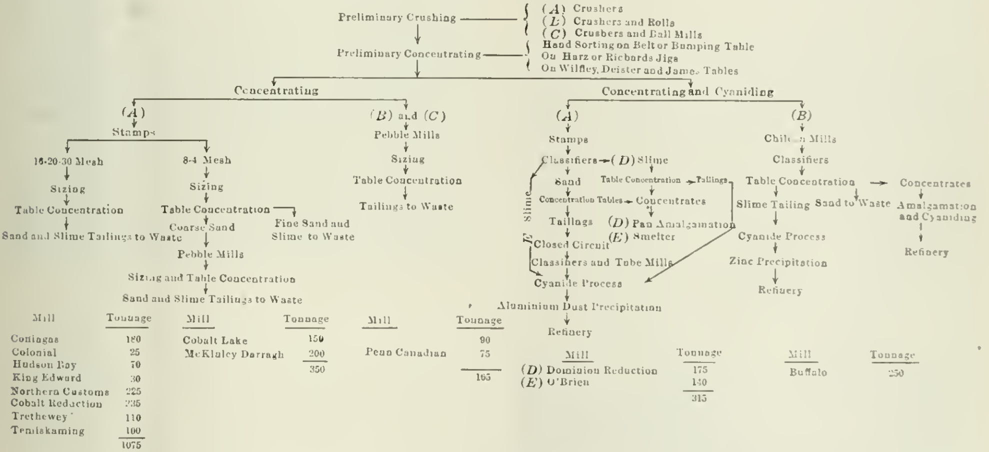


FIG. 1—COMPARATIVE FLOW SHEET OF COBALT CONCENTRATORS (FROM DATA COMPILED BY FRAZER D. REID)

Excepting the friability of the various silver minerals, the low-grade ore presents no serious difficulties in concentration. The effect of an increased proportion of these minerals in the ore is to raise the grade of slime tailing, and consequently increase the loss unless this product is cyanided. Thus, at one of the mills where cyanidation of slime tailing is practiced, when the concentrator was treating a 40-oz. ore the slime tailing carried as much as 60 oz. per ton, but when the grade of mill feed dropped to 20 oz. the slime was reduced to about 8 oz.

The ratio of concentration varies at the different mills, but is high. An average probably would give between 45:1 and 50:1, with an extreme range of 25:1 and 100:1.

A comparative flow sheet of Cobalt concentrators, including those at which cyanidation also forms a part of the treatment, is given in Fig. 1. This is compiled from data contributed by Mr. Fraser D. Reid, superintendent of the Coniagas mill, and is abridged from a more extended flow sheet published by him.[2] This shows at a glance several features which impress the visitor at Cobalt mills: (1) the general use of stamps, and (2) the lack of stage crushing and concentrating.

### Crushing and Grinding

The use of stamps or rolls on Cobalt ore is a point of controversy among millmen in the district, although generally the seal of approval is placed on stamps if we may judge by their more extended use. Fig. 1 shows that stamps are used for the crushing of slightly over 80 per cent of the total tonnage concentrated. An objection to stamps is the quantity of slime and fine sand produced, amounting to 30 or 40 per cent of minus 200-mesh pulp when crushing through 16 to 30-mesh screen. This objection is emphasized in those cases where no regrinding is practiced, and where fine screens are used on the batteries to insure original grinding to the requisite degree of fineness. It is claimed that rolls will make not more than half the amount of fine produced by stamps. The Chilean mill also slimes less than stamps: thus, a feed of —6 + 12 mesh material ground in a Chilean mill through 12-mesh screen gave only 6 per cent minus 200-mesh.

The advocates of stamps claim that rolls are inefficient machines in crushing the tough conglomerate; and even some of those who favor rolls, when condition of product alone is considered, admit that rolls do not stand up to the work and that crushing cost is increased by their use. At the same time it is probable that large heavy rolls have not been given a trial. Another argument in favor of stamps is that the ore can be ground in them to the requisite degree of fineness in one operation, thereby eliminating regrinding machinery. This leads, of course, directly to a related point on which also there is a difference of opinion.

### Stage Grinding and Concentrating

To anyone who is familiar with general concentration practice on base-metal ores, such as occur in the western United States, the absence of stage reduction and concentration in most Cobalt mills will be a matter of surprise. The general tendency is to crush in one operation to a degree of fineness which experience shows will liberate most of the valuable metal and minerals. There are exceptions, notably the McKinley-Darragh and Cobalt Lake mills, wherein the crushing is done in stages by successive machines, with intermediate classification and concentration.

---

[1] This journal, July, 1914.

[2] Milling Practice in Cobalt, by Fraser D. Reid, *Bulletin*, Can. Min. Inst., May, 1914.

It is true,. as already pointed out in our last issue, that all of the silver in these ores will not be released from gangue save by very fine grinding, and the millman must determine the economic limit of crushing. This seems to have been found between 16 and 30 mesh at different mills. Those who advocate single-stage crushing maintain that by grinding to, say 20 mesh and concentrating, a 16 to 20-oz. ore will yield a tailing carrying only 3 to 4 oz. silver per ton. To make a further recovery from this tailing would require very fine grinding which would not be profitable. In support of this view, Mr. Reid gives the following screen analysis of a tailing obtained from such treatment, showing the uniform silver content of the different grades down to minus 200 mesh, where there is a sudden increase.[3]

Screen Analysis of Sand Tailing from 16-Mesh Battery Discharge

| Mesh | Per Cent Weight | Oz. Silver per Ton | Per Cent Value |
|---|---|---|---|
| + 30 | 22.1 | 3.2 | 22.6 |
| + 60 | 31.8 | 3.0 | 30.3 |
| + 100 | 28.6 | 3.0 | 27.4 |
| + 200 | 13.1 | 2.5 | 10.5 |
| — 200 | 4.4 | 6.5 | 9.2 |

Opposed to single-stage grinding are those who feel that the concentrating practice can be improved by crushing in several stages, with suitable classification and concentration at each step. While the advocates of this procedure are in the minority, they feel that progress in concentration in the district should be along this line and that future economic conditions will demand a change in this direction. Perhaps a suitable line of crushing and grinding machinery for this work would be gyratory and jaw breakers, large heavy rolls, disc grinders and pebble mills.

A new tube mill liner, known as the Globe, is being used at the McKinley-Darragh mill and is regarded favorably. Like the El Oro it consists of metal ribs with spaces in which the pebbles become wedged, but the ribs extend around the inner face of the tube instead of lengthwise. This liner is being used also at the Hollinger mill in the Porcupine district.

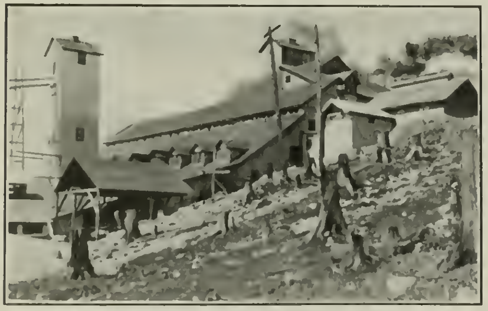


FIG. 2—CONIAGAS MILL, COBALT

With regard to classification, it may be said that it is not practiced to the degree considered advisable and essential elsewhere. Perhaps the high specific gravity of the concentrate makes this necessary, but it is certain that more extensive classification is now being adopted in some plants, and the operators of those mills feel that the change is showing an improvement in results.

Harz and Richards jigs are used for coarse concentration, but the former predominate. They are relied upon to recover silver nuggets and high-grade ore, which ordinarily are removed by skimming the jig beds. Wilfley, Deister and James tables are found throughout the district, the two latter being in favor and exceeding the first in number.

### The Coniagas Mill

One of the typical concentrators of the district is the Coniagas, a view of which is given in Fig. 2. The ore is crushed in stamps, classified and concentrated, the tailings going to waste. Average mill feed contains 34 oz. silver per ton; sand tailing, 3 to 4 oz., and slime tailing, 6 to 7 oz. Preliminary treatment ahead of stamps results in cutting the grade of original feed in half, so that the stamp discharge contains about 16 oz. silver per ton. Concentrates are shipped to the company's smelter at Thorold, Ont. A flow sheet of the mill is outlined in Fig. 3.

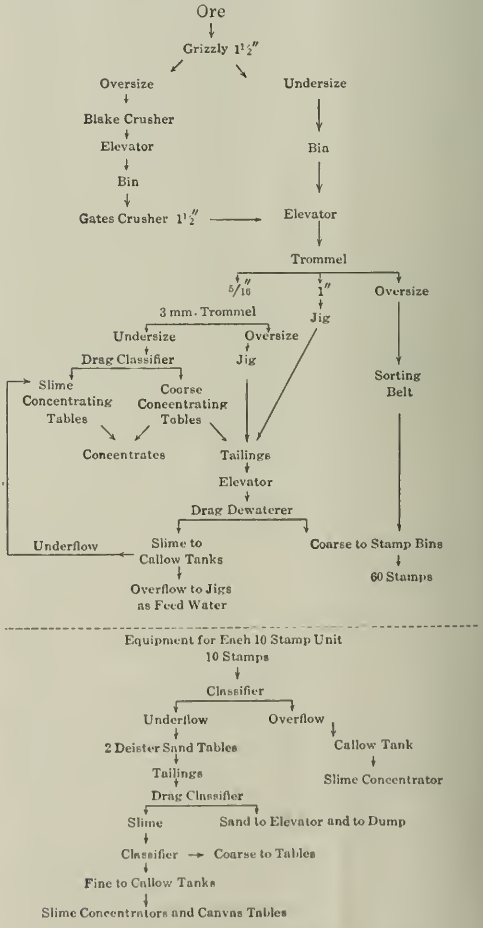


FIG. 3—FLOW SHEET, CONIAGAS MILL, COBALT

Manganese and chrome steels are used in crushing and grinding machines and wherever apparatus is subjected to excessive abrasion by the ore. Jaws and cheek-plates on Blake crushers, and concaves and mantles on gyratories are manganese steel. The same metal is used for buckets on dry and wet elevators. Buckets on dry elevators have been in service for three years, handling 180 tons of ore per day, and probably are good for the remaining life of the mine. On wet elevators these buckets have lasted for 15 months and probably will show a life of two years. Trommels also are of manganese steel, as are the mortar liners. The latter are 1 inch thick and sectionalized so that the part most subject to wear can be reversed and then replaced without discarding the entire plate. This practice has resulted in doubling the life of the liners.

---

[3] Ibid.

### Tailings Disposal

The Coniagas mill is so situated that sand tailings have to be stacked. As shown in the flow sheet the sand and slime are separated by a drag classifier, the slime being concentrated further and the sand sent to the tailing elevator, which is shown at the left in Fig. 2. Sand is discharged from the elevator into a launder with the minimum amount of water required for transportation and flows to the point of discharge where it stacks as shown in Fig. 4. The cost of this method of stacking is 0.7 cent per ton. A sample of the tailing is cut out at the elevator discharge and returned to a pilot table in the mill, where the attendant is able to observe the presence of any metal or mineral that may be going out of the mill due to faulty operation.

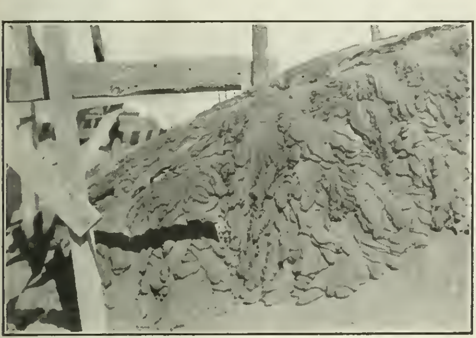


FIG. 4—SAND TAILINGS STACKED AT CONIAGAS MILL

Another system of stacking sand tailing, by aerial tramway, is shown in Fig. 5. This is the method adopted at the Buffalo mill. The sand is dewatered in the mill by a drag conveyor which discharges into a bin from which the tram buckets are loaded. There are two buckets attached to the running cable, one being at the loading station while the other is dumping. The buckets dump automatically and the sand is sluiced down the launder by water conducted to the dump through a pipe shown in the view.

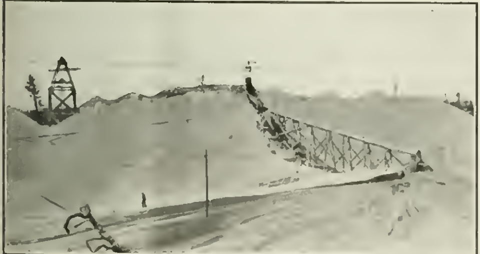


FIG. 5—STACKING SAND TAILINGS AT BUFFALO MILL, COBALT

### The Trethewey Mill

In Fig. 6 the treatment given at the Trethewey mill is outlined in considerable detail. This plant comes within the same classification as the Coniagas, stamps being used for crushing, followed by simple classification and concentration on sand and slime tables. There is no regrinding. At one time a Huntington mill was used as a regrinder, but it was abandoned as being wholly unsuited to the work of grinding such tough ore. James and Deister tables are used, and a Deister-Reid slime table recently has been added. This latter is a modification of the Deister slime table by Mr. Reid, superintendent of the Coniagas mill, and is finding considerable favor in the district.

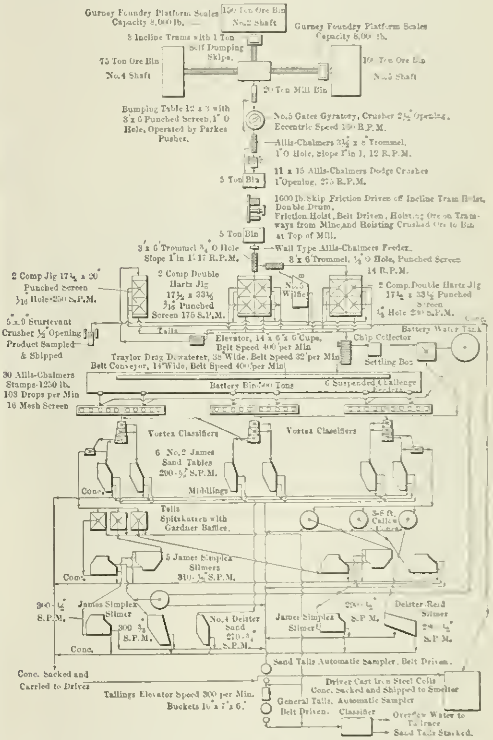

Gurney Foundry Platform Scales Capacity 8,000 lb.
150 Ton Ore Bin No.2 Shaft
Gurney Foundry Platform Scales Capacity 8,000 lb.
3 Incline Trams with 1 Ton Self Dumping Skips.
75 Ton Ore Bin No.4 Shaft
100 Ton Ore Bin No.5 Shaft
20 Ton Mill Bin
Bumping Table 12 x 3 with 3' x 6 Punched Screen, 1" O Hole, Operated by Parkes Pusher.
No.5 Gates Gyratory, Crusher 2½" Opening, Eccentric Speed 1?? R.P.M.
Allis-Chalmers 3½' x 8' Trommel, 1" O Hole, Slope 1" in 1, 12 R.P.M.
11 x 15 Allis-Chalmers Dodge Crusher 1" Opening, 275 R.P.M.
5 Ton Bin
1600 lb. Skip Friction Driven off Incline Tram Hoist, Double Drum. Friction Hoist, Belt Driven, Hoisting Ore on Tramways from Mine, and Hoisting Crushed Ore to Bin at Top of Mill.
5 Ton Bin
3' x 6' Trommel ¾" O Hole Slope 1" in 1'-17 R.P.M.
Wall Type Allis-Chalmers Feeder.
3' x 6' Trommel, ⅛" O Hole, Punched Screen 14 R.P.M.
2 Comp Jig 17½ x 20" Punched Screen 1/16" Hole-250 S.P.M.
2 Comp Double Hartz Jig 17½ x 33½ 3/16" Punched Screen 175 S.P.M.
No.5 Wilfley
2 Comp. Double Hartz Jig 17½ x 33½ Punched Screen ⅛" Hole 2?0 S.P.M.
5" x 9" Sturtevant Crusher ½" Opening Product Sampled & Shipped
Tails
Conc.
Battery Water Tank
Elevator, 14" x 6" x 6" Cups, Belt Speed 400' per Min
Chip Collector
Settling Box
Traylor Drag Dewaterer, 38" Wide, Belt Speed 32' per Min
Belt Conveyor, 14" Wide, Belt Speed 400' per Min
30 Allis-Chalmers Stamps-1250 lb. 103 Drops per Min 16 Mesh Screen
Battery Bin-?00 Tons
6 Suspended Challenge Feeders
Vortex Classifiers
Vortex Classifiers
6 No.2 James Sand Tables 290-⅝" S.P.M.
Conc.
Middlings
Tails
Spitzkasten with Gardner Baffles.
3-8 ft. Callow Cones
5 James Simplex Slimers 310-⅛" S.P.M.
Conc.
300-⅛" S.P.M.
James Simplex Slimer
300 ⅜" S.P.M.
No.4 Deister Sand 270-¾" S.P.M.
James Simplex Slimer
2?0-⅛" S.P.M.
Deister-Reid Slimer 2?0-⅛" S.P.M.
Conc.
Sand Tails Automatic Sampler, Belt Driven.
Conc. Sacked and Carried to Drier
Drier Cast Iron Steel Coils Conc. Sacked and Shipped to Smelter
Tailings Elevator Speed 300 per Min. Buckets 10" x 7" x 6".
General Tails, Automatic Sampler Belt Driven.
Classifier
Overflow Water to Tailrace
Sand Tails Stacked.

FIG. 6—FLOW SHEET, TRETHEWEY SILVER COBALT MINE, LIMITED

A successful device for removing chips of wood from the ore before it passes to the stamps is in use at this mill. It is placed at the drag dewaterer which receives the jig tailings. It consists of a series of brushes mounted on a belt traveling across the trough of the dewaterer at right angles to the travel of the drag. The brushes dip beneath the surface of the water, engage the floating chips and remove them at one side. The device has been of great assistance in avoiding the blinding of battery screens and preventing the accumulation of fine wood pulp in the concentration system.

### Cost of Concentration

Mr. Reid gives the cost of concentration at the Coniagas mill as $1.32 per ton of ore treated.[*] This excludes the cost of coarse crushing and preliminary concentration, and refers only to the work done at and beyond the stamps. It includes, however, allowances for depreciation, interest on investment, insurance, etc. At another mill the cost of all work, including coarse crushing and concentration, is given as $2.67 per ton. Details of various concentrating mill costs given by Mr. Reid are shown below.

---

[*] Ibid.

**Coniagas Mill.**—Capacity, 180 tons. Sixty stamps and concentrating equipment cost $75,000. Battery feed is 2-in. size and finer, and is crushed through 16-mesh screen. Assay of battery discharge is 16 oz. silver per ton. Recovery is 11.8 oz.; value, @ 55 cents, $6.49.

| | Cost per Ton | |
|---|---|---|
| Stamping: | | |
| Power | $0.157 | |
| Operating | .072 | |
| Shoes | .022 | |
| Dies | .011 | |
| Screens | .004 | |
| General | .016 | $0.282 |
| Concentrating: | | |
| Labor | .109 | |
| Power | .037 | |
| Supplies | .025 | |
| General | .008 | |
| Fuel, etc. | .032 | 0.211 |
| Marketing, 11.8 oz. silver at 4.6c | | 0.523 |
| Depreciation, 10 years | | 0.138 |
| Interest on investment, 6 per cent | | 0.046 |
| Insurance, 2.2 per cent | | 0.030 |
| Assay loss, allowance 1.34 per cent | | 0.087 |
| Total | | $1.317 |

**Beaver Mill.**—Capacity, 80 tons. Pebble mills and concentrating equipment cost $50,000. Assay of mill feed 19.5 oz. silver per ton. Recovery is 15.65 oz.; value, @ 55 cents, $8.61.

| | Cost per Ton |
|---|---|
| Marketing, 15.65 oz. silver at 5.9c | $0.923 |
| Working costs | 1.290 |
| Depreciation, 10 years | .198 |
| Insurance, 2.2 per cent | .043 |
| Interest on investment, 6 per cent | .090 |
| Assay loss, allowance 1.34 per cent | .115 |
| Total | $2.659 |

**In another mill** of 200 tons capacity, the cost of which was $125,000, the mill feed assays 30 oz. silver per ton. Recovery is 25.5 oz.; value, @ 55 cents, $14.025. Costs include preliminary crushing and jigging.

| | Cost per Ton | |
|---|---|---|
| Operating | $0.292 | |
| Power and light | .250 | |
| Repairs | .152 | |
| Management | .120 | |
| Steel | .072 | |
| Fuel | .046 | |
| Assaying and sampling | .043 | |
| Screens and general | .018 | |
| Oil | .009 | $1.002 |
| Depreciation, 10 years | | .201 |
| Interest on investment, 6 per cent | | .060 |
| Insurance, 2.2 per cent | | .044 |
| Assay loss, allowance 1.34 per cent | | .188 |
| Marketing, 25.5 oz. silver at 4.6 per cent | | 1.173 |
| Total | | $2.668 |

### Cyanidation of Cobalt Ores

It can be readily understood that the proposal to reduce the complex ores of Cobalt by the cyanide process was received with skepticism. Consequently the successful application of this method may be regarded as a triumph in hydrometallurgy, as pointed out by Mr. Clevenger in our recent symposium on the complex-ore problem.[5] Containing, as they do, combinations of silver, arsenic, sulphur, antimony, cobalt and nickel, these ores do not appear attractive to the cyanide metallurgist, and it is not surprising that concentration and smelting have formed the predominating basis of treatment. Advocates of the latter system claim an advantage on low-grade ore, where the stamp discharge carries from 12 to 15 oz. silver per ton after about an equal amount has been removed by preliminary coarse crushing, sorting and jigging. Possibly the margin of profit in favor of either process is narrow in any event, but when the Nipissing company contemplated the erection of a low-grade mill for the treatment of, say 30-oz. ore, and considered the merits of concentrating and cyaniding, the latter process was adopted. Preliminary estimates showed a profit of $1.59 per ton in favor of cyaniding,[6] and the results since obtained in practice have more than confirmed these estimates. Certainly the advantage gained by a quick conversion of ore into marketable bullion is a considerable benefit offered by cyaniding as compared with concentrating and smelting.

Excluding those mills at which slime tailing from concentration only is cyanided, there are others in which cyanidation, with and without amalgamation, is the reduction process employed. At the Dominion Reduction and Buffalo mills the ore is first concentrated, after which the slime tailings are cyanided and the concentrates treated by a process of cyanide-amalgamation. At the Nipissing high-grade mill[7] cyanide-amalgamation is employed, while at the same company's low-grade mill cyanidation only is used. The process of cyanide-amalgamation in use at the Buffalo is the same as that first used at the Nipissing high-grade mill.

### The Nipissing Mills

The Nipissing Mining Company operates two mills: one for high-grade ore, which has been in operation since February, 1911, and the other for low-grade ore, which went into commission in November, 1912. Since the construction of the latter mill all ore is received at a central washing and sorting plant, where the rich ore is selected and sent to the high-grade mill, the balance going to the low-grade plant. The washing plant and low-grade mill are situated on Nipissing hill, across Cobalt lake from the town of Cobalt. A view of this mill, as seen from the town, is shown in Fig. 7. The high-grade mill is shown in Fig. 8, and a flowsheet is given in Fig. 9 showing the relation of the two plants.

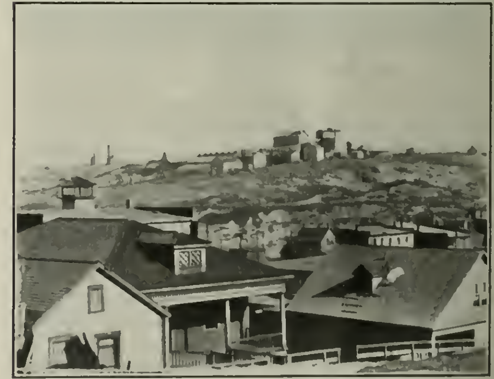


FIG. 7—NIPISSING LOW-GRADE MILL, FROM TOWN OF COBALT

### Washing and Sorting Plant

Run-of-mine ore contains, on an average, 50 to 55 oz. silver per ton. It is crushed to 3-in. size before delivery to the bins of the washing plant, where it is drawn into cars and weighed on registering scales that give an accurate record of all ore received from the mines. In the succeeding operations the ore is washed, sized, hand-picked and jigged for the removal of the high-

---

This Journal, May, 1911, p. 300.

[6] Mill and Metallurgical Practice of the Nipissing M. Co., by James Johnston, January, 1914, *Bulletins* Can. Min. Inst. and Amer. Inst. of Min. Eng. Abstracts in this journal, March, 1914, p. 189, and May, 1914, p. 318.

[7] Nipissing High-Grade Ore Mill, Cobalt, by R. B. Watson, *Eng. & Min Jnl.*, Dec 7, 1912

grade portion, containing about 2500 oz. silver per ton, which is sent to the high-grade mill. The jigs handle two sizes of ore, one between 0.5 and 1.5 in., and the other between 3 mm. and 0.5 in. The discarded low-grade ore coarser than 1.5 in. is crushed to that size before going to the battery bins; the balance, including jig tailings, is sized through 3-mesh screen, the oversize going to battery bins and the undersize to the tube mills. In this way the batteries are relieved of handling about 10 per cent of the ore which is already crushed fine enough for tube mill feed.

FIG. 8—NIPISSING HIGH-GRADE MILL, COBALT

### Cyanide-Amalgamation of High-Grade Ore

In 1913 the high-grade mill treated 1832 tons of ore containing 4,804,928 oz. silver, of which 1200 tons was Nipissing ore averaging 2501 oz. per ton. The tonnage treated at the high-grade mill is between 1½ and 2 per cent of the total ore mined and sent to the washing plant. The recovery is 99 per cent, of which 97 per cent is by amalgamation and 2 per cent by cyanidation.

The main step in the process, which was devised by Charles Butters and G. Howell Clevenger, consists in grinding the ore for 10 hours in a tube mill with mercury and strong cyanide solution. The ore is first crushed to 20-mesh size. A tube mill charge depends somewhat on the grade of the ore, but consists in round numbers of about 3 tons of ore, 4 tons of mercury, 1½ tons of 5 per cent cyanide solution and 6 tons of pebbles. The tube mill is of special construction and is adapted to receive compressed air to aid in cyanidation. Fine grinding is necessary to liberate all of the silver, and at the end of the operation practically all of the pulp will pass a 200-mesh screen.

The tube is charged and discharged through manholes. When the pulp is ready to be discharged the manhole covers are replaced by screens through which the pulp and amalgam flow into a settling tank. Amalgam and mercury are drawn from the settler into a clean-up pan and then into canvas filters, and the amalgam is finally retorted.

The ore residue is given a further treatment by agitation in cyanide solution, followed by decantation and vacuum filtration. The solution is precipitated by zinc shavings in the usual manner. An unusual sight is presented in the zinc boxes owing to the change of color of the solution as it flows from upper to lower compartments. The head solution is clear and colorless, but it gradually acquires a reddish tint and exhibits a marked coloration in the last box. This is due to the presence of nickel in solution and probably results from the reduction of nickel cyanide by zinc. When this colored solution is again oxidized by aeration it resumes a normal appearance.

### Recovery of Cobalt Residue and Silver Bullion

The filter residue contains mainly cobalt and nickel minerals, some silver and mercury. The total consumption of mercury in the entire operation of producing bullion is about 20 lb. per ton of high-grade ore, of which about 12 lb. remains in the residue. The balance is lost in volatilization and handling. The residue carries also 20 to 40 oz. silver per ton, 8 to 10 per cent cobalt, 4 to 6 per cent nickel and 30 to 40 per cent arsenic. It is sold to manufacturers of cobalt products, who pay for the cobalt and 85 per cent of the silver. In 1913 the company sold 1659 tons of residue, netting $62,484.

Retorted amalgam and zinc precipitate are melted in a reverberatory furnace and oxidized with air to slag off impurities. The resulting bullion is 999 fine. A small blast furnace is used periodically to smelt reverberatory skimmings and flue dust, and the resulting bullion is further refined in the reverberatory furnace. A baghouse has recently been constructed to recover dust and fume from the blast, reverberatory and retort furnaces, thus adding another refinement to a process which yields a commercially complete recovery of silver from a complex high-grade ore.

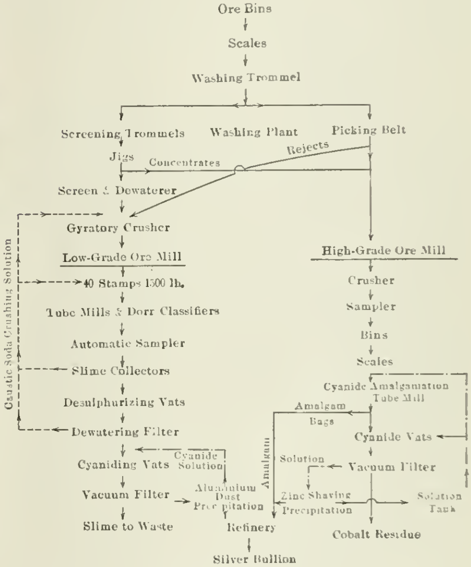


FIG. 9—FLOW SHEET, NIPISSING MILLS, COBALT

Interesting and successful as the Nipissing high-grade mill has been, it is possible that the process may be supplanted by direct cyanidation. Research, which has been such a prominent feature of Nipissing metallurgy in the past, is constantly under way and is now being directed toward the evolution of a scheme to treat high-grade ore and concentrate by cyanidation. Preliminary laboratory experiments have been sufficiently encouraging to warrant proceeding with tests on a larger scale, which are now under way.

### Direct Cyanidation of Low-Grade Ores

The low-grade ore rejected at the washing and sorting plant is treated by the cyanide process as outlined in Fig. 9. The principal features are (1) a wet desulphurizing process which liberates silver from its mineral combinations and renders it soluble in cyanide solution; (2) precipitation of silver with aluminium dust, and (3) the recovery of about 92 per cent of the silver from a 30-oz. ore, in the form of bullion 997 fine. Briefly, the process consists in grinding to slime in caustic soda solution; desulphurizing by contact with aluminium; filtering to remove caustic soda solution; treating with cyanide to dissolve silver; filtering and precipitating the solution with aluminium dust; melting and refining the precipitate.

The milling plant is a model of excellence in design, construction and arrangement, and shows the value of good preliminary engineering. The arrangement of machinery and the relation of the several departments show a freedom from complications which are so apparent in many poorly designed mills. Here even the casual visitor may quickly gain an idea of the system of treatment. All machines are readily accessible for inspection and repairs, and cleanliness is evident throughout. In short, it is apparent that Nipissing ideals are comprehensive and extend to every department of the work.

### Extremely Fine Grinding Necessary

The ore is ground in 0.25 per cent. caustic soda solution, with 5 lb. of lime per ton of ore added at the battery bins to aid in slime settlement. The equipment for this part of the treatment consists of forty 1500-lb. stamps, four 6 ft. by 20 ft. tube mills and seven duplex Dorr classifiers. In order to secure a good extraction by cyaniding it is necessary to grind the ore extremely fine—practically all minus 200-mesh. For this reason the capacity of tube mills and classifiers is unusually large when compared with stamp capacity.

The battery discharge, 7 parts of solution to 1 of ore, is distributed to four of the Dorr classifiers. These machines have higher overflow weirs than usual to prevent the discharge of fine sand; they are also about 5 ft. longer than standard machines and have bevel-gear drives. The slime overflow passes to collecting tanks, and the sand discharge is delivered to the two coarse-grinding tube mills and ground with 40 per cent of solution. The tubes, in turn, discharge to three more Dorr classifiers, the slime overflow from which passes to collecting tanks, while the fine sand is delivered to the two fine-grinding tube mills which discharge back to the set of three Dorr classifiers. Thus the sand is kept in a closed grinding and classifying circuit until it is ground fine enough to overflow the weirs of the classifiers.

### Desulphurizing with Aluminium

The ore ground in caustic soda solution is collected in tanks and allowed to settle. The excess solution is collected in overflow launders and through decanters until the remaining pulp consists of about 1½ parts solution and 1 of slime. It is then ready for the desulphurizing treatment, which decomposes the refractory minerals that contain part of the silver in the ore. Most of the silver is in the metallic state, but some is combined. Thus in a 30-oz. head sample, approximately 80 per cent of the value may be present as metallic silver and 20 per cent in mineral combinations.

The desulphurizing process is the result of research by J. J. Denny of the Nipissing staff.[8] His explanation of the decomposition of silver sulphide by the treatment with aluminium in alkali solution is represented in the following equations.

$$2Al + 2NaOH + 2H_2O = Na_2Al_2O_4 + 6H$$
$$6H + 3Ag_2S + 6NaOH = 3Na_2S + 6H_2O + 6Ag$$

Similar reactions occur with sulphantimonides and sulpharsenides. These reactions are brought about by grinding the thickened alkaline pulp in a 4 ft. by 25 ft. tube mill, lined with aluminium and carrying a load of about 4000 lb. of broken aluminium ingots. This is followed by mechanical agitation in vats lined with sheets of aluminium. At the end of 24 hours' agitation the pulp is filtered, discharged with about 26 per cent solution and treated by cyanidation.

### Cyanide Treatment

Solution of silver is accomplished by 48 to 60-hr. agitation of a pulp consisting of 2 parts 0.25 per cent cyanide solution and 1 of dry slime. The agitation vats have mechanical stirrers and air lifts which are kept in constant operation. The air lift is placed near the periphery of the vat and has two discharge openings one above the other pointing in opposite directions. The combined effect of mechanical stirrer and air lift is a very thorough mixture and agitation of the pulp. After agitation the charge is allowed to settle. Clear solution is decanted and the remaining pulp is stored in tanks where it is kept in agitation until drawn to the filter.

Both alkali and cyanide filters are of the Butters stationary type and are equipped with the latest form of Butters vacuum filter leaf.[9] The cake is dislodged by the application of water from a pipe extending along the top on the outside of each leaf, and no reverse internal pressure is applied. The cyanide filter has 80 leaves and handles charges of 35 to 40 tons in about three hours. The cake is discharged with 26 per cent moisture. The adoption of the new filter leaf has resulted in a number of benefits. The cost of filtration is reduced, filters require less attention, and the fabric lasts longer. Ten-ounce duck is now used, which stands the acid treatment better than the lighter fabric formerly employed.

### Precipitation by Aluminium Dust

Although zinc dust precipitation was a part of the process as originally planned, it was abandoned because experimental work, showed a rapid fouling of solution and loss of dissolving power. Further tests with aluminium dust finally led to the adoption of that precipitant with beneficial results. It was found that mill solution did not become foul, and that it was even more active than freshly prepared solution in dissolving silver. Other benefits obtained in practical operation are (1) the regeneration of 1 2/3 lb. cyanide per ton of ore treated, and (2) the recovery of a silver precipitate carrying about 27,000 oz. per ton. The subsequent melting and refining of this precipitate yields bullion 997 to 999 fine.

There is a tendency for soluble sulphides to form and accumulate in the barren solution. In order to oxidize these sulphides, the barren solution is aerated by means of air lifts before it is used again. His investigations on this point lead Mr. Denny to believe that soluble sulphides form as a result of the reduction of thiosulphates by aluminium in alkaline solution. If these sulphides were not oxidized in some manner they would tend to form potassium sulphocyanide, and this salt, Mr. Denny points out, is not convertible into soluble sulphide by aluminium and caustic soda except under conditions of concentration that do not obtain in mill solutions.

Aluminium does not accumulate in solution as some have surmised, but remains constant at about 0.08 per cent to 0.1 per cent, as in the case of zinc. Accumulation is prevented by precipitation of the aluminium as calcium aluminate during the cyanide operation, and this passes out of the mill with the filter residue. It will be recalled that the battery pulp is charged with lime to aid in settlement, and that the residue from the dewatering filter still carries 26 per cent of the original alkaline solution with its quota of lime. When cyanide solution carrying some aluminium is added to this pulp the reaction between lime and aluminium occurs.

---

[8] *Min. & Sci. Press*, Sept. 27, 1913

[9] This leaf was described in this Journal Jan., 1914, p. 65, and a similar leaf was referred to in our issue for July, 1911, p. 479. Recent patents relating to Butters slime filtration are numbered 1,078,991, 1,096,132, 1,100,217-18-19-20-21-22-23-67.

$$Na_2Al_2O_4 + Ca(OH)_2 = CaAl_2O_4 + 2NaOH$$

### Cost of Producing Silver

In his annual report for 1913, Mr. R. B. Watson, general manager, gives the following interesting data on Nipissing operations. The low-grade mill was in operation 86.8 per cent of the possible running time, and treated 77,240 tons of ore. Stamp duty was 6.09 tons per stamp per day. The recovery of silver from the beginning of operations on Nov. 11, 1912, to Dec. 31, 1913, was 91.85 per cent. The ore-treatment cost, based on the tonnage given above, was $4.132 per ton, distributed as follows:

| | Cost per Ton |
|---|---|
| Crushing at mine | $0.163 |
| Aerial tramway | .100 |
| Surface tramways | .117 |
| Picking plant | .217 |
| Crushing | .081 |
| Battery | .267 |
| Tube mills and classifiers | .547 |
| Slime collecting | .448 |
| Intermediate filtering | .127 |
| Treatment | 1.021 |
| Filtering and discharging | .186 |
| Clarifying and precipitation | .301 |
| Refining | .127 |
| Heating | .113 |
| Water supply | .031 |
| Construction | .286 |
| | $4.132 |

### Consumption of Supplies at Low-Grade Mill

| | Lbs. per Ton | Cost per Lb. | Total Cost per Ton Ore |
|---|---|---|---|
| Cyanide | 5.190 | $0.1500 | $0.7785 |
| Caustic soda | 3.200 | .0214 | .0684 |
| Lime | 6.640 | .0040 | .0266 |
| Aluminium dust | .568 | .3373 | .1917 |
| Aluminium plates | .268 | .2438 | .0654 |
| Aluminium ingots | .964 | .2207 | .2128 |
| Flint pebbles | 6.540 | .0098 | .0646 |
| Ore pebbles | 3.100 | .... | .... |
| Coal for heating | 30.160 | .0029 | .0881 |
| Power, K. W. H | 51.570 | .0115 | .5933 |
| | | | $2.0894 |

The cost of producing 4,552,173 oz. of silver in 1913, at both low- and high-grade mills, was 24.09 cents per oz., which is 6.7 cents higher than in 1912, when practically the same quantity of silver was produced, *viz.*, 4,688,000 oz. The increased cost is due to the fact that nearly half the production in 1913 came from low-grade rock, whereas in 1912 practically the entire production was from high-grade ore. The cost of producing silver in 1913 is distributed as follows:

### Cost of Producing Silver—Based on Production of 4,552,172.59 Ounces and 77,240 Tons Milled

| | Per Ton Ore | Per Oz. Silver |
|---|---|---|
| Hydraulicking and clearing land | $0.554 | $0.0094 |
| Diamond drilling | .093 | .0016 |
| Development and exploration | 3.685 | .0625 |
| Stoping | 2.191 | .0372 |
| Loading and sampling | .064 | .0011 |
| Assaying, engineering and research | .151 | .0025 |
| Administration and office | .381 | .0065 |
| Boarding house and camp maintenance | .278 | .0047 |
| Insurance and taxes | 1.013 | .0172 |
| General and legal expense | .366 | .0062 |
| High-grade mill | .618 | .0105 |
| Low-grade mill | 4.144 | .0703 |
| Custom Milling by Nova Scotia Co | .017 | .0003 |
| Depreciation | .793 | .0135 |
| Marketing product | .305 | .0052 |
| Corporation, New York Office and Travelling | .155 | .0026 |
| | $14.808 | $0.2513 |
| Less rents and interest | .615 | .0104 |
| **Total operating cost** | $14.193 | $0.2409 |

### Dominion Reduction Mill

This is a custom mill treating ore from the Kerr Lake, Crown Reserve, Cobalt Comet, Drummond Fraction and other mines in the district. The method of ore-treatment is outlined in Fig. 10. As the mill is run on a custom basis, few data of operation are available. One of the features of the dry crushing department is the recent installation of a 48-in. Symans horizontal reduction disc, the only one in the district.

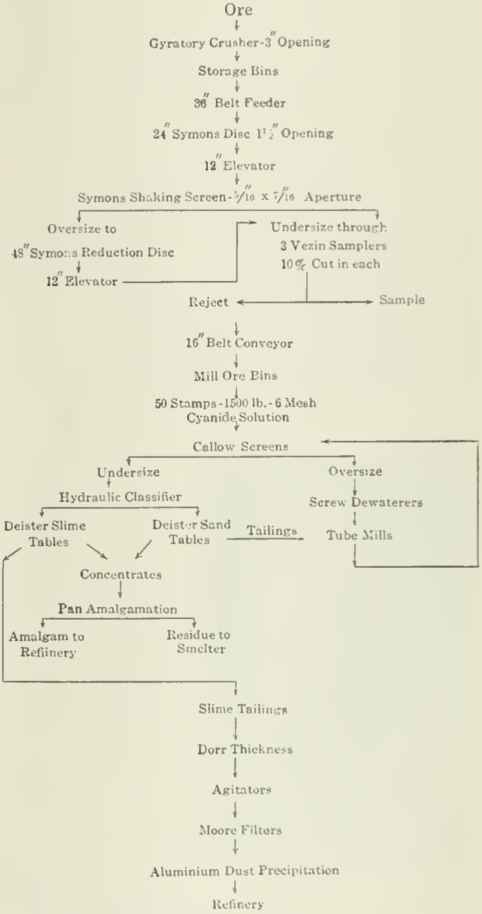


FIG. 10—FLOW SHEET, DOMINION REDUCTION MILL, COBALT

The ore is stamped in solution carrying 3½ lb. cyanide and 2½ lb. protective alkalinity. Sodium hydroxide and lime are used for the latter purpose, about one-third caustic soda and two-thirds lime. After sizing through Callow screens the pulp is classified for concentration, and sand tailings are ground in tube mills in closed circuit with the screens. Concentrates receive a special treatment by pan amalgamation in strong cyanide solution. The products are (1) amalgam, which is melted and refined, and (2) a residue containing about 150 oz. silver per ton, 33 per cent arsenic, 6 per cent cobalt and 3 per cent nickel. This residue is sold for further treatment.

There are no unusual features about the cyanidation of the slime tailing, except that aluminium dust is used as a precipitant of silver from the pregnant solution. The dust is fed at a constant rate of 3 lb. per hour when solution pumps are running, regardless of the grade of the solution. Mixing is accomplished in a small wooden tank, in the bottom of which runs a screw propeller that forms a vortex. Precipitation efficiency varies with the grade of solution and is more nearly complete when the solution carries about 10 oz. silver per ton. Thus from a 9-oz. head solution the tail solution carried only 0.12 oz., while from a 4-oz. head solution the tail solution would carry 0.82 oz.

In conclusion the writer desires to record his appreciation of the many courtesies extended during his visit to the mills in Cobalt, where every facility was afforded for gathering the notes on which these articles have been based.

## The Late Walther Feld

The death of Walther Feld on March 15, this year, in Linz on the Rhine, Germany, has left a void in the chemical profession which will be very difficult to fill.

Feld was a genial investigator, an unexcelled chemist and a never-tiring pioneer in the field of chemical technology, which, combined with a loving personality, made him a friend much sought after.

THE LATE WALTHER FELD

Feld was best known through his origination of the barium industries in Germany, and a walk along the banks of the Rhine shows plainly to what extent his labors in this field bore fruit, as the principal industry for many of these villages depends upon the production of barium compounds. He created this industry when there was no market for the product, but due to his untiring efforts, this market was found for the benefit of the present producers.

Being called upon to investigate tars and oils in coal gases, he was led to establish a theory of fractionately separating various tar products in the gas through distillation by the own heat of the gas, and his results in this endeavor can be pointed to with pride in many of the European coke-oven works. Having once taken in hand the condensation of coal gas, he did not stop until he had solved the old problem of purification in closed vessels—something which gas men had been seeking for the last fifty years. Not only did he make it possible to purify in closed vessels, but he was also able to combine the hydrogen sulphide contained in the gas with its radical of ammonia, and thus produce sulphate of ammonia* without the use of sulphuric acid, and perhaps his only regret before joining those in the Great Beyond was the fact that one of the largest installations of his direct sulphate recovery system, and which had been built under his supervision, was to be placed in operation ten days after his death. While this disappointment during the few days of his illness had to be borne, he still had the satisfaction of seeing the rosy dawn of success in a field which had been abandoned by many others.

While Walther Feld was not known as well in the United States as he was in Europe, his demise is of interest to all engaged in like pursuits, as he hoped that many of the chemical principles laid down by him would be followed by his brother chemists the world over.

In closing the notice of his death, nothing of greater praise can be said than the following words which appeared in *Die Chemische Industrie*, published in Germany, namely: "The barium industry as well as industries connected with tar and ammonia must thank him for the new paths which he has broken, and in the history of the development of German chemical industries the life work of Walther Feld must for all time remain an imperishable page of fame."

Fred. H. Wagner.

## Niagara Falls Meeting of American Electrochemical Society

For the fall meeting of the American Electrochemical Society, to be held in Niagara Falls from Thursday to Saturday, Oct. 1 to 3, the local committee has announced the following provisional program:

On Thursday morning there will be a session for the reading and discussion of papers, in the afternoon an excursion to Fosters' Flat, in the evening a smoker "with an unusual program."

On Friday morning a visit will be paid to plants and power houses, with a high-voltage display at one of the power houses. In the afternoon there will be a session for the reading and discussion of papers, and in the evening a dinner, followed by an illustrated lecture.

On Saturday morning and afternoon an experimental symposium will be held at the Fitz Gerald Laboratories, and in the evening a kommers at the Fort Schlosser Club.

The privilege of the local golf course will be extended to members. Other special features of the program will be announced later.

## Salt Lake Meeting of American Institute of Mining Engineers

The Salt Lake City meeting of the American Institute of Mining Engineers will be held from Monday to Friday, Aug. 10 to 14, 1914.

Technical sessions will be held in the evenings of Monday, Tuesday, Wednesday and the morning of Thursday in the ballroom of the Hotel Utah.

The program of excursions is very full and exceedingly interesting. Practically the whole of Tuesday will be devoted to a trip to the mines of Bingham, the concentrating mills of the Utah Copper Company at Magna and Arthur, and the Garfield smelter.

On Wednesday the smelter of the American Smelting & Refining Company at Murray and the smelter of the United States Smelting, Refining & Mining Company at Midvale will be visited in the morning and the smelter of the International Smelting & Refining Company at Tooele in the afternoon.

A trip to Saltair Beach is scheduled for Thursday afternoon and an automobile trip to Big Cottonwood Canyon, with picnic luncheon, for Friday. On the evening of Friday there will be a banquet at the Hotel Utah.

---

*See his article in the July, 1912, issue of *Metallurgical and Chemical Engineering* (vol. X, p. 395)

# Research Work in the Laboratory and Mill

BY WARREN F. BLEECKER

Technical men seem to be agreed that the time is not far distant when industrial concerns will realize very forcibly the necessity for greater efficiency in operations and processes of a chemical and metallurgical nature. Competitive conditions will probably require certain classes of manufacturers to produce not only better grades of materials, but also to produce them somewhat more cheaply than in the past.

We may also imagine a time, not far distant, when the people as a whole may caution owners of mines and mills not to waste by crude manufacturing methods substances which are at the same time useful and rare. New minerals will be found in workable quantities, and processes must be devised for them. Methods of treatment for lower-grade materials will be required from time to time. And finally it must come to pass that processes will be devised which will be dependent upon by-products from industries wholly diverse and unrelated.

These things are now being thought of more and more, and men of all grades of technical training and ingenuity are being called upon to attack the problems already discerned by farseeing directors of industrial organizations.

## Research Ability

It has been observed that a great many managers of plants, chemists, and young technical graduates have some difficulty in approaching certain classes of experimental work which they are called upon to do. This is especially true when a man does not possess a natural aptitude for research work, or in case the problem to be solved involves a branch not directly within his experience. For example, the manager of a wet concentration mill may find it necessary to investigate the possibilities of other methods of treating his ore, such as magnetic separation, or cyanidation. Facing such a problem, he should feel assured that he has access to certain avenues of investigation which are wholly within the limits of his ability and experience. The fact of his proficiency along his present line of work should give him assurance of being able to carry to a successful issue such experiments as he may undertake.

It is a distinct economic loss for a man of average intelligence to avoid lines of experimental work, essential to his business, but which he assumes to be out of his immediate mental grasp, because they happen to involve special knowledge somewhat apart from his previous experience. While it may take a lifetime to become an authority on electrometallurgy, for example, a working knowledge of the principles of this art may be acquired almost by wishing it.

While recognizing the necessity for expert and thorough knowledge we should not overlook the advantage of a perspective which embraces accurate detail and at the same time mellows it.

Each man who is doing his work well has acquired a certain mental equipment which is adapted to his present needs. I wish to point out that this equipment, with the aid perhaps of the knowledge of a few fundamental principles, will serve equally well in such new problems as may be attempted. In a word, nothing within reason is impossible to the man with sufficient courage to tear apart the veil of mystery surrounding unfamiliar fields and confidently examine the various elements. Such a procedure will yield ample returns for the small effort invested.

It would be unnecessary to offer suggestions to trained investigators and presumptious to advise men expert in their particular lines. But of these I ask the privilege of stating facts broadly, because once the attempt is made to state exceptions and to define the innumerable phenomena secondary to a given principle, there is immediately set up a perplexity, however small, in the mind of the beginner, and the entire purpose is defeated.

I do not think it necessary in the discussion of electrolysis, for example, to send out a general alarm as to the theories of osmosis, ionic migration, polarization, decomposition voltage, equilibria, and kindred phenomena. The specialist understands the importance of these things from sources of unquestioned authenticity; when the other fellow gets to a point where he can quibble over definitions and theories, he will not have been far misled by getting a few facts in the rough.

To him who has had the privilege of receiving instruction from high-class industrial engineers of our colleges and schools, or to him who possesses a genius for experimental work, I have but little to offer. It is to that class of men who are called upon to perform tasks somewhat outside their training or experience that encouragement should be given, not by laying down rules and laws for an indefinite number of specific cases which might arise, nor again to destroy or distort individual methods or habits of thought, nor again by attempting to diagram every imaginable case which might arise, but by speaking of certain basic principles, indicating possible avenues of approach, by assuring them that many new things are actually within their experience, and finally by pointing out a few sources of error and fallacy which are certain to be encountered.

## Scope of Metallurgical Research

Research may be undertaken with any one of a number of different objects in view. It may be desired to give an ore a preliminary treatment in order to obtain a product previously rejected; a demand may have arisen for the improvement of a certain product without an expensive and unnecessary improvement of other products; it may be desired to improve the grade of all products; some reagent used in the processes may have become more expensive or rare; a new and different ore body may demand treatment; a general shaking up of processes to the end of greater efficiency may be required; and there are hundreds of other reasons why researches are undertaken. In each case there will be found a logical chain of possible incidents between the requirement and the hoped-for result, and this chain ought to be diagrammatically stated for constant reference.

## Statement of the Problem

One of the first things an experimenter should do is to state his problem as definitely as possible in writing. He should state the result hoped for, the allowable variations of present practices, allowable costs, grades of products, available raw materials, etc.

I have found it useful to imagine a process or operation completed, and then look back over it to see what further could be desired. There is an old saying as to the superiority of hindsight over foresight. Sometimes one may be credited with considerable foresight when it has been nothing more than hindsight. I have heard this expressed a little more elegantly by one of my professors in mathematics. He called it "Back Illumination." This back illumination leads us to be more truthful with ourselves, for the reason that a careful survey of that which we are supposed to have done will surely reveal defects in a system which were at first sight hidden by our natural optimism.

I do not recommend that one should attempt to imagine all of the finished details at the outset. On the contrary, to determine details is the object of the research. But I insist that a plan of action should not be left to chance reactions and phenomena which may from time to time be observed. Before a series of experiments can be successfully attempted one or more properties or peculiarities must be known, which properties have the possibility of lending themselves either to or toward the end desired. When, as is often the case, advantageous properties are not known, a definite and thorough research must be made until they are found. It is not within the limits of my experience that this is impossible.

### Optimism Versus Proof

Without going into the psychology of the thing, I am convinced that there is no other profession which exacts from its members such a rigid adherence to truthfulness and honesty between man and man. In no other profession that I know of does there exist such an amazing and constant series of opportunities for optimism and hopefulness to shade into realities without the formality of rigorous proof. It is altogether too easy to assure one's self that a little more heat, a little more reagent, or a little more time will result in a higher extraction or a greater degree of purity, without actually performing the operation. Among other sources of opportunity for self-deception may be mentioned the neglect of traces of impurities which will surely multiply in finished products; lack of appreciation of the time element; neglect of allowance for wear and tear of apparatus, and finally, the failure to put down in cold figures the losses at various stages of the treatment through which a product must pass.

In all cases the experienced metallurgist will base his final conclusions on recorded observations. It is a practice to be recommended to the investigator who is working along lines in which he is not expert.

### The Importance of Qualitative Results

In the exploration of new fields, the importance of obtaining results which are only qualitative, can hardly be overestimated. The idea of the primary mass has even a more profound meaning in chemistry and metallurgy than in freehand drawing. If one will but take time to block out his problem he will obtain a perspective worth many times the effort. The technical research man must allow his train of thought and his habits a certain flexibility, in that he should be able to rush through almost countless operations, making them serve his purpose without the useless labor of completing each for the sake of art. In other words, he should be able to learn many lessons from unfinished work without jeopardizing his instinct of accuracy. I have found it a most difficult thing to train young technical men in the habit of knowing when an experiment is finished.

I will illustrate this point as follows: It is known that the values in certain radium-bearing ores may be partially separated by a system of concentration involving flotation in a fluid. Assuming that an experimenter in attacking this problem had determined with a gold pan, a microscope, and an electroscope, that the process had a commercial possibility, he might proceed to verify this in a number of ways, but I will suggest a simple experiment.

One hundred grams of ore pulverized to suitable fineness is agitated with water in a litre florence flask. After allowing this to settle for a few minutes, the supernatant slime is decanted off, more water is added, and the operation repeated. Washing is continued without regard to the quantity of water until further agitation removes no slime. Assuming that water concentration is to be alone considered, it is obvious that under the conditions the maximum values were removed from the coarser sands. In other words, providing all of the slimes were to be saved and all of the tailings were to be rejected, the difference between the analysis of the original ore and the analysis of the tailings, expressed in percentage, would represent the highest possible efficiency.

In order to ascertain the maximum limit of recovery, therefore, it would only be necessary to know the original value of the ore, the weight and value of the tailings. In this particular instance the labor saved in rejecting the slimes would be several times that necessary to wash and dry the tailings, because of the difficulty in filtering and drying the slimes. It will be obvious that this operation will have to be repeated a large number of times on the various classes of ore under consideration, and for this reason, the saving of time will be a great factor in getting without delay a solid foundation for the refinements which must come later on.

The same rule will apply during the study of the quantities of water necessary for concentration; once it is established that a certain separation can be effected, it is entirely unnecessary to check the results simply because there is an opportunity. Time is so very valuable that it should not be wasted in doing unnecessary work.

Almost all results which are obtainable in a small way, especially through the application of laboratory methods, cannot be taken at face value. In other words, they must have the proper interpretation before reliable conclusions can be drawn. The experimenter must by experience familiarize himself with large-scale operations before he attempts to draw conclusions as to costs, extractions, recoveries, grades of products, and other operating data.

### Laboratory Reactions

On the other hand, there are but few reactions peculiar to the laboratory. As a rule, mill operations are more nearly quantitative and may be obtained in a more satisfactory manner. Further than this there are certain classes of reactions which in the mill are almost marvels of simplicity and perfection but which are practically impossible in a small way. Among these may be mentioned magnetic roasting, salt roasting, gas washing, extraction by agitation, magnetic separation, wet concentration, and superheating.

Unfortunately there seems to be a widespread misunderstanding concerning the relation between laboratory work and mill operations. It is a very common belief that laboratory operations are very unreliable and even dangerous when considered as a basis of a proposed mill operation. That mistakes have been made and that a prejudice has been nourished therefrom, is due more to a lack of common sense than to inherent defects in small operations.

Chemical analyses do not, as a rule, give finished products, nor allow of simple multiplication in order to become of commercial application. While a standard method of tungsten assay results in the actual production of a minute quantity of tungstic acid, and the assay of gold results in the production of the pure metal, there are many other elements which are not determined by weighing small quantities of a finished, marketable product. Experience has taught us, however, that so many cubic centimeters of permanganate means a definite percentage of lime, and that a given quantity of standard cyanide tells us the percentage of copper. Because no further significance is attached to such reactions they have not fallen into bad repute by being introduced as mill processes.

One of the first things learned in chemistry is the group separation of certain of the elements. During that awful first year of the study of qualitative analysis the student picks up more misinformation than he can forget during the remainder of his life. While he is being taught methods he thinks he is learning principles. It is the application of these false principles which contributes so largely to the misunderstanding of the proper relation between experimental laboratory work and mill operation.

If one will only look upon laboratory experiments as sources of information and not as achievements; as indicative of detached facts rather than complete processes; as representing arguments, and not conclusions; we may then free ourselves from fundamental error in this matter. If we but realize that chemical reactions, like human actions, taken singly or in different settings, reveal tendencies rather than habits, the situation will be more sane, and our conclusions more worthy of our efforts.

It is often said: "Of course, you can do it in the laboratory, but in the mill it will be different." Nothing can be farther from the truth. In the entire realm of chemistry and metallurgy, I defy any man to mention as many as half a dozen operations which can be done only in the laboratory. A blast furnace is more efficient than a blowpipe, a jet of steam will heat a tank of liquor in the same time a beaker is heating over a burner, and with modern apparatus, tons of iron hydrate can be filtered, washed and dried as quickly as grams of the same material are likewise treated in the laboratory.

It is almost discouraging to find so many still speaking of the laboratory as a place where wonders are worked. I believe that it is possible to get at the bottom of such unscientific ideas and root them out forever.

It is, of course, a matter of common knowledge that the general conditions affecting chemical reactions are temperature, concentration, excess of reagents, presence of interfering elements, physical conditions of the reacting substances, and the tendencies of the various reactions to proceed at given rates. Among such a large number of conditions it follows that the number of combinations is very large. The lack of control of any one condition may mean lack of control of all; and there may be more than one condition during the inception of a process which is neither properly controlled nor understood.

In the treatment of small quantities of ore in the laboratory, there is always the danger of using a quantity of reagent entirely out of proportion to that which is allowable in a large way. Five cubic centimeters of sulphuric acid used to decompose a gram of ore containing 5 per cent copper means 182 tons of acid per ton of copper. Five grams of sodium carbonate necessary to decompose one gram of roscoelite carrying 2 per cent vanadium pentoxide means 445 tons of soda ash per ton of metallic vanadium.

The proper place to start an investigation is the laboratory, however large the final scale of operation is to be. There are a great number of reasons for this procedure, and, so far as I know, there are no reasons against it.

### The Process

It may be pointed out that the really important reactions of a new process are very few—usually not more than one. These reactions must be studied at close range in order to ascertain all favorable and unfavorable conditions. There will be numberless secondary reactions and phenomena, many of which will in themselves present problems. At best the thorough investigation of unfamiliar reactions and the resulting products requires scores, and sometimes hundreds of experiments. All else aside, with only one lifetime at his disposal, one cannot afford to begin a comprehensive research on a large scale.

We may arbitrarily divide an ore treatment process into three parts: the dressing of the ore, the extraction of the values, and the recovery of the products.

It will be apparent that no one of these departments may be completely organized without due regard to at least one of the others. For example, certain phases of roasting, concentrating, or leaching may determine the limits, and in a large measure the manner, of grinding. It is equally true that the separation or extraction process will have to conform to the requirements of the final production. In other words, the entire process will, as a usual thing, have to be built up as a unit. If the manner of grinding is decided upon before the extraction process is fully worked out, the experimenter has seriously endangered his prospects, because of the limits within which he must now work.

It often happens that the first-discovered and most desirable reactions of a series of proposed processes for ore treatment occur at a more or less advanced stage. In such cases the metallurgist will build toward such reactions from the ore pile, and from the finished products as well. The salt roasting of vanadium ores, and the dry chlorination of sulphide ores illustrates this principle.

### Magnitude of Experiments

It would be a serious mistake to confine experimental work to the laboratory until a series of processes are completely organized. Let it be supposed that a satisfactory extraction of a sulphide ore with chlorine could not be obtained in laboratory apparatus on account of lack of control of temperature, agitation, etc. It would, therefore, be necessary to use such apparatus as would give satisfactory results, although the ore for the experiments might have to be ground on a bucking board, and the resulting solutions treated in beakers. That is to say, because it is necessary to perform one of a series of operations on a large scale, I do not think it advisable to work on this scale entirely.

Archimedes, or Franklin, or Hubbard should have formulated a rule something like this: Get your information with as little expenditure of time, money, and material as possible, but get it.

A gentleman with the ink on his Doctor's degree hardly dry, approached a manufacturer with a claim that he could save a certain more or less valuable by-product at that time being wasted. That is to say, he had a process, admittedly in the embryonic stage, which sounded plausible to the manufacturer. After some discussion the chemist was employed and given permission to direct the perfection and installation of his process. Inasmuch as he had made no claim that the process had been tried or that it had been developed to the operative stage, it would have been the logical thing for him to have spent a few months or weeks as the case may have warranted in studying the proposed reactions and planning certain details. Instead of doing this, he ordered a quantity of special apparatus and began mill operation. Things went wrong here and there, and he started again and again until he had everybody disgusted and wishing him out of the way. Of course, he failed and lost what would have been a good job. As his proposition was afterward explained to me I am inclined to believe that it had merit, and that it was worthy of investigation. This young man could easily have made a showing if he had but realized the necessity for common sense. It does not require the intellect of a Newton nor the genius of an Edison to get results. One must have a good store of common sense and the courage to work, work, and work. If the idea is a good one, the results will finally unfold in an amazingly simple manner.

### Control of Quantities and Conditions

It is so easy to get rid of a small quantity of an objectionable impurity in the laboratory with a few drops of this or that reagent that the investigator may for the time pass over the possible cost or difficulties involved in a large way. It is also relatively easy to obtain a complete precipitation, or decomposition, or dehydration by adding a few drops of alkali, a few hundred milligrams of peroxide, or by adding a few calories of heat. Although it is not the usual thing, these factors may multiply geometrically when applied in the large way. This is not an uncommon thing in drying semi-colloidal precipitates; a cake twice as thick requires more than twice as long and much more heat for dehydration.

Another matter worthy of attention is that, as is well known, many reactions depend largely upon the strength of liquors, both as to valuable content and excess of reagents. For our purpose let us assume that the concentration of a solution as obtained from an extraction process is of the proper degree for precipitation. It is desirable to precipitate at or near the boiling temperature and this condition may be easily and quickly done by heating the solution over a flame. It will be obvious that while the concentration is not appreciably altered during the laboratory treatment, the method of heating in the mill will be different. More or less time may elapse between the extraction and precipitation in the mill as compared with the same operations in the laboratory, resulting in a loss of heat, and therefore requiring more time for heating. Although the solutions may be easily and cheaply heated by the introduction of live steam, dilution may occur to such an extent as to materially lessen the efficiency of the reactions.

Such obstacles are by no means fatal to processes, but they should be foreseen and plans for compensating for differences in concentration, etc., must be carefully worked out before one has the right to claim a successful issue.

### Interpretation of Results

It is almost a truism to say that the interpretation of quantitative laboratory results is quite as important as the interpretation of other phenomena which may fall under observation. For example, the fact that a certain extraction was obtained in the concentrating experiment mentioned above does not mean that exactly such results will be obtained in practise. It means that under the conditions of washing, etc., the limit has been reached, and that somewhat lower recovery may be expected. A microscopical examination of the tailings may suggest a slightly modified treatment, providing the possible recovery is not satisfactory. On the other hand, a careful examination of the slimes may reveal physical properties which will lead to the investigation of other modifications. The experiment has confirmed the supposition that a mechanical separation is possible and it remains for countless other experiments to completely disentangle the knot which Nature has so cunningly woven.

In the study of ore extraction, it often occurs in a series of experiments that after a given treatment the percentage extracted is strikingly constant. This is very significant in many cases, and may mean that the values exist in more than one state of oxidation, or that the treatment leaves unaffected only that quantity which is differently mineralized.

As a rule, one may obtain results in a large way which are more nearly quantitative than those obtained in the laboratory. Conditions of temperature, concentration, agitation, acidity, volume, etc., may be kept more nearly constant, and readily within the required limit.

In working with a new ore it is a part of the metallurgist's business to assure himself that the sample at hand is reasonably fair and representative; otherwise he may work serious injury to himself and his employer. The whole, if practicable, should be thoroughly mixed and sampled according to standard methods, and in almost all cases, a complete analysis should be made.

### Some Valuable Accessories

Assuming that ore treatment is under discussion, it is a very natural thing to make a preliminary survey with the aid of a few simple accessories before undertaking a profound research. For example, the following equipment is indispensable:

A complete set of screens.
A rough balance, 1 gram to 1 kg.
A gold-washing pan.
A horseshoe magnet.
A powerful reading glass.
A microscope with micrometer slide.

With the screens, the experimenter will be able to determine among other things whether the vaules are evenly distributed throughout the gangue, or segregated to a greater or less degree in portions having different hardness, or other physical property affecting the size. A screen test may also indicate the proper fineness of crushing and at the same time indicate possible losses through dust and slimes.

A gold-washing pan may reveal the presence of elements which were not suspected, and will sometimes bring to light minerals which are present in quantities so small as to escape detection in the process of chemical examination.

A most valuable aid to the metallurgist is the microscope. With it one may not only study the size, form, structure and other characteristics of ore particles, but also observe certain classes of chemical reactions. With a few milligrams of ore on a glass slide one may study the action of such solvents as may be thought worthy of trial, and the resulting solutions may be further examined under moderately high power in investigating certain phases of precipitation or purification. As the dynamic test of metals discloses properties ont even suggested by static tests, so the microscope will reveal facts beyond the ken of the analyst. For example, a very excellent and certain method of controlling the roasting of telluride ores was devised by Mr. Willliam H. Davis in Boulder County. He suspected that the diminishing sulphur content of the ore as roasting proceeded was not a true index of the decomposition of the telluride mineral. Accordingly he took samples at various stages of the roasting process and separated the gold-bearing mineral from the gangue by washing in a gold pan. An examination of the minute particles from the various samples under the microscope at once showed the physical and chemical conditions resulting from under-roasting, properly roasting, and over-roasting. Mr. Davis not only proved his point, but succeeded in obtaining an extraction much higher than when using only chemical control.

### A Study of the Ore

In the study of ore extraction it is always desirable to know, if possible, the manner in which the values are combined, both chemically and physically. With such information it is usually not difficult to attack the mineral directly, and in some cases it is quite possible to leave the present gangue matter wholly unattacked.

In some classes of ores it is also necessary to know the potential reduction. This together with a knowledge of the analysis, will usually throw much light upon the existing conditions of the values, as to whether they are partially reduced or partially oxidized. An ore may be examined as to its state of oxidation in several ways, such as weighing a portion which has been previously ignited under such conditions as will remove the combined water, organic matter, etc., and subsequently oxidizing and noting the increase in weight. In an experiment with ore containing sulphur or certain other elements, it will obviously require various and ingenious methods to avoid compensating errors, but there is usually a way to do it. A partial solution is some neutral reagent, such as sulphuric acid, and direct titration with standard permanganate or some other agent will also lead to information.

### Value of Approximations

The research engineer should accustom himself to grasp the meaning of percentages rapidly, and should be able to make such rough mental calculations as will at times allow quick work. Refined calculations are of great importance and have their place, but rough and ready approximations will save valuable time and material. A set of lead chambers could be seriously damaged if the man in charge stops to figure when he sees a storm coming up, or if he finds that the nitre man has forgotten his charge an hour ago.

Together with this faculty of rapid approximation should go a keen sense of order of magnitude. This is a most useful possession and will keep one from many errors, plausible enough on the face, but easily recognized by their very absurdities. For example, men who have a properly trained sense of the order of magnitude are almost free from errors resulting from a misplaced decimal point, especially in slide-rule calculations. The technologist should have such an intuitive sense of the fitness of things that will cause him to question at once results, sizes and forms which are not in keeping with accuracy or good practise.

Often in working with new products which are not of enough importance to warrant the development of routine analysis, the analyst may report results which seem to him to be perfectly reasonable, but which to the metallurgist are absurd. Perhaps I may have been unfortunate in meeting men whose ideas of the fitness of things were limited, but my experiences have convinced me that the problem is real.

### The Order of Magnitude

A gentleman with several letters after his name suggested to me in all seriousness the catching of rainwater in an open tank for the purpose of supplying a plant with distilled water. That a year's rainfall would not have lasted an hour did not appeal to him in the least. The story of the engineering student who designed a brace one one-hundredth of an inch in diameter is surely not exaggerated. I knew an engineer who attempted to stop a hole threaded for ½-in. pipe by simply shoving in a short ½-in. bolt. He explained that he couldn't find a ½-in. plug and that the bolt would keep in some of the water anyway.

A certain large engineering concern was permitted to do the engineering on an electrode-regulating device. They were told that the electrode and holder would not weigh more than 100 lb. They sent a mechanism guaranteed to lift something like 9000 lb. Another engineering firm in or about New York City sent out a generator with a rated amperage of 2650, while the copper busbars from the brush holders had a section of less than half a square inch. In addition to this, the connections between the brush holders and these bars were of cast iron.

We see advertisements of washing machines which will do the family washing for 2 cents, and of an apparatus which will furnish distilled water at less than 3 cents per ton. I think the whole matter is worthy of serious consideration.

The experimenter should be constantly on the lookout for unusual reactions and phenomena, and be prepared to take advantage of them, should they be suited to his purpose. It is usually upon reactions somewhat out of the ordinary that new processes are based. In other words, the most successful technologist does not always think of copper in terms of a hydrogen sulphide precipitate.

In the investigation of a complete process of ore treatment the experimenter is trying to determine two things: the efficiency of the process, and the cost. To a large extent these two things are interdependent, although the first question is answered only by experiment, and the second may be answered largely by calculation in many cases.

It must be remembered that the cost per unit of value recovered is finally going to be the point upon which the success or failure of the process is determined. A low efficiency at low cost is usually more likely to prove profitable than a high efficiency at high cost. The experimenter must at all times keep in mind certain limits beyond which he cannot go in the use of expensive chemicals, quantities of chemicals used, and the number of operations through which the ore and products must pass.

### Choice of Reagents

Excepting for the purpose of obtaining information of a strictly chemical significance, it is usually not advisable to make use of reagents which are known to be inapplicable to mill use. This, of course, depends wholly upon the nature of the problem, and the manner of attacking it. There is a tendency with all of us to ward the use of such powerful reagents as nitric acid, sodium peroxide, potassium chlorate, metallic zinc, concentrated sulphuric acid, and the like. These things do have limited uses in large operations, but one should have a thorough appreciation of quantities, costs, and difficulties of handling such chemicals before attempting to use them in works operation. A good example of the use of an expensive reagent in the treatment of very low-grade ores is found in the cyanide process. This process, however, is a law unto itself and its like is hard to find. The use of mercury for amalgamation, and the use of platinum in the contact process are other examples, illustrating the absurdity of formulating a rule to be followed blindly. It may be said, however, that the use of expensive reagents must be accompanied with more care and expert attention than the use of such materials as common salt or sulphuric acid.

There are many instances in laboratory experimentation in which an expensive reagent may be used as a matter of convenience and saving of time. For example, it is sometimes desirable to oxidize solutions in order to obtain favorable conditions for precipitation or filtration. In the laboratory the easiest procedure is to add hydrogen peroxide. Quantitative experiments and subsequent calculation will usually show that for a given oxygen content sodium peroxide is cheaper, liquid chlorine is cheaper still, and finally electrolysis is the cheapest of all. Under some conditions air may be used for oxidation of solutions, and besides its cheapness it has other very desirable properties. The experimenter is entirely justified in using peroxide of hydrogen for his small experiments, providing he is certain it has no other effect than the addition of oxygen and that the method finally to be employed is likewise applicable.

### Cyclic Processes

In general, the experimenter should be cautious in the contemplation of cyclic processes; that is, those which involve the recovery of reagents over and over again. The chief source of danger in processes of this nature is the accumulation of impurities which finally render the solution inactive. An example of a successful cyclic process is the chamber process for making sulphuric acid. Although the conditions are highly favorable for the recovery of nitric acid and its subsequent reuse, it is significant that the nitre pots are very important adjuncts to the plant.

There was proposed not long ago a process for the treatment of ores with nitric acid. The nitric acid solutions containing nitrates were to be treated with sulphuric acid, and the nitric acid recovered in absorption chambers such as are used in the processes for the fixation of nitrogen. The difficulties to be encountered at the various steps of the process would probably be very great, but this is not all. The designer of the process evidently overlooked the fact that nitric acid owes its activity to the ease with which the $NO_3$ ions decompose. Thus the thing is defeated even before it has begun.

Perhaps the most satisfactory cyclic process of large magnitude is the cyanide process. The history of the development of this process shows that the early investigators met with their share of trouble, and but for the fact that it was so revolutionary and so necessary, it is altogether possible that it might long ago have been relegated to the metallurgical graveyard.

The continued reuse of solutions in processes for the extraction of copper has been tried repeatedly, and in some instances with a measure of success.

Under certain favorable conditions it is possible to recover chemicals with profit. As a rule, however, it is more desirable to adopt counter-current systems of leaching and washing in order to get the full value of the reagents added, and finally discard spent and barren solutions together with whatever impurities they may carry. Spent solutions of acid and alkali are not often recovered with profit.

### Electrometallurgy

It is generally conceded that the application of electrical energy to metallurgical operations is increasing geometrically. Representing as it does a form of energy powerful yet easily controlled, ready for work at the throw of a switch, it is all the more remarkable that still greater use is not made of it. Rapid as the advance of electrometallurgy has been, it deserves to come into greater use. To my mind, the greatest retarding influence is the lack of full appreciation of the possibilities of the application of electrical energy to ores and ore products.

To the research man, unfamiliar with the commercial application of electrical energy, it may be said that the experimental difficulties in this branch of work are no greater than in any other. As in any other branch of science, there are certain rules and laws to be understood, but they are of interest and wholly logical. After all, common sense is nine-tenths of the electrometallurgical game.

Aside from power and lighting purposes, electricity is employed in metallurgy for two general purposes: heating and electrolysis.

Electric current may be supplied either as alternating or direct, the greatest difference between these two forms being that in the one case the current is rapidly reversed throughout the circuit, and in the other the flow is constantly in the same direction. The very rapid reversing of a current gives rise to effects not met with in direct current, but which for our present purpose need not be discussed.

While either alternating or direct current may be used for heating purposes, only direct current can be used for electrolysis since in this latter phenomenon a continuous removal of electric charges is brought about at opposite electrodes. It may be considered that negative charges are given up at the anode and positive charges given up at the cathode. Obviously, electrodes connected to a source of alternating current become consecutively positive and negative in such rapid order that the electrolytic effect of one instant is destroyed or counteracted during the next.

In the electrolytic cell or electric furnace it is desired to obtain all of the energy potentially in some form of matter: a pound of aluminium, a pound of silicon, a pound of zinc, each represents a definite number of kilowatt-hours of electrical energy.

### Electrolysis

An impression which is more prevalent than is generally supposed, is that the electric current by virtue of its passage through a solution or other medium, exerts force upon it in such a manner as to cause chemical reactions to take place regardless of any strictly chemical habit to the contrary. In other words, it is wrongfully assumed that the electric current may set aside chemical laws and perform various chemical acts wholly impossible without its aid.

We may assume that the electric current creates no chemical change in the interior of an electrolyte and be entirely correct. Any effect of the electric current which concerns the technical investigator is due to the removal of electric charges from chemical elements or groups of elements (ions) at the electrodes, and at no other place. What the current really does is to change the electrical conditions of compounds which are in contact with the electrodes and thus allow the element so electrically discharged a certain chemical freedom. The exercise of this freedom is sometimes mistaken as a phenomenon of the current itself.

If we will allow ourselves to look at this thing from a common sense point of view, we may for a time place to one side the mass of theories and highly specialized information (which indeed we shall find of great value later in our experience) and observe the action of electrolysis as a thing of extreme simplicity. What the practical man wants is results. If he has a sound working knowledge of electrolytic phenomena, he may not yet know all that is possible, but he certainly will know that some things are impossible.

### Electrolytic Decomposition

The following illustration has been chosen as typical of electrolytic decomposition:

Sylvanite, a telluride of gold and silver, may be decomposed in an electrolytic cell. It is only necessary to place the crystals in contact with the cathode of a cell, the electrolyte in which is sodium hydrate. The tellurium is rapidly dissolved, while the gold and silver settle to the bottom as a black powder. The electric current releases metallic sodium on the surface of the crystal and from this point on the action is strictly chemical, and would take place if the current were discontinued. If the tellurium compound were placed at any portion of the solution not in contact with an electrode it would remain unchanged, however much electrical energy might be passing through the cell. If the electrolyte were sodium chloride and the sylvanite were placed on the anode decomposition would result from the action of the chlorine deposited upon it. In this case the gold would go into solution.

### A Maximum Chemical Concentration

The electrolytic cell provides a very efficient means of obtaining a maximum concentration of elements or groups in a state of freedom. For example, by the electrolysis of a salt of sodium we may obtain a decomposition at the cathode such as would be possible with sodium element, because, indeed, we actually plate metallic sodium on the cathode and any conductor of the first class which is in contact with it. Likewise we may get the action of pure chlorine by electrolysis of a chloride. The products of electrolysis are formed in relatively small quantities, and in many cases instantly reunite, but they continue to be formed as long as the electrolyte holds out and the current continues to pass.

### Secondary Reactions

When common salt is electrolyzed, the two products are sodium and chlorine. The chlorine is partly dissolved in the solution and partly evolved in the gaseous state. The metallic sodium is immediately set upon by the water present and sodium hydrate results. The chlorine which is dissolved reacts upon the sodium hydrate to form hypochlorite, and other reactions occur, depending upon conditions of temperature, concentration, etc. It is obvious, however, that the formation of caustic or hypochlorite results from purely chemical causes, and would take place if metallic sodium were placed in water, or chlorine were led into a solution of lye.

### Electrode Phenomena

If the electrolyte be sodium sulphate there will be plated at the respective electrodes, sodium and the group $SO_4$. Since neither of these can exist alone in aqueous solution, a decomposition of water takes place with the evolution of hydrogen at the cathode and oxygen at the anode. It will be perfectly apparent that if the anode is of such a material as will form a soluble sulphate, it will be attacked and dissolved. It will also be apparent that by proper selection of electrolyte and electrodes the full effect of either the hydrogen or the oxygen may be obtained for reduction or oxidation respectively. For chemical and mechanical reasons, the size and shape of the electrodes have to be considered, and to obtain the best results, the electrodes must be proportioned according to the current available and the effect desired. Either oxidation or reduction may be obtained by properly regulating the relative size of the electrodes.

In the greater number of electrolytic operations it is desirable to use an anode which is not attacked. Unfortunately our choice is limited to platinum, graphite, fused iron oxide, lead or gold in some cases, and possibly a few others. In case the cathode is metallic, it will not be attacked. In case the cathode is an oxide it will either be reduced in situ or dissolved and finally find its way to the anode. As an illustration showing how both of these effects may take place simultaneously, a plate of copper vanadate (a compound of copper and vanadium oxides) employed as a cathode will become a plate of sponge copper, while the vanadium pentoxide will be dissolved and tend to be plated out on the anode.

There are many desirable reactions which may be obtained by using a soluble anode; that is, one which is attacked by the negative group or element plated out upon it. For example, vanadate of lead may be formed by electrolyzing a solution of sodium vanadate and using a metallic lead anode. Likewise tungstate of iron may be made by using an electrolyte of sodium tungstate with an iron anode.

The electric current will of itself neither oxidize nor reduce, neither decompose (except the electrolyte itself) nor synthesize; but it will give freedom to elements and groups of elements which in turn will do these things. Such is electrolysis.

Compounds may be broken up by virtue of their elements having been plated out at the electrodes, and these elements may reunite to form either the same or different compounds. The formation of such salts would take place at the moment, however, if the current should be discontinued.

Electrolytic cells may be divided into two general classes: those in which the two electrodes are in the same compartment, and those in which the electrodes are in separate compartments.

In the simple cell there may be obtained such reactions as electroplating, refining of metals, production of metallic salts by anodic decomposition, oxidation, reduction, etc. In the compartment cell, of which there are several types, there may be obtained practically all electrode products, the cathode material being kept separate from the anode material. Perhaps the largest industrial application of the compartment cell is in the manufacture of caustic soda and chlorine.

### Compartment Cells

The most widely used type of compartment cell is the diaphragm cell, in which the electrodes are separated by a porous partition. This partition serves to prevent mechanical mixing, but allows the passage of positive and negative elements and groups which finally reach the electrodes and become electrically discharged and free. Depending upon its porosity, the diaphragm will also allow a certain amount of diffusion and the resulting contamination of the compartment product. The investigator may make a diaphragm of filter paper, canvas, wood, clay, asbestos, alundum, silica, or in fact of any porous non-conductor. For very small experiments, porous cups may be used. At one time I used large flower pots with considerable success.

Another type of compartment cell is one in which the electrodes are separated by glass or other insulating material, the partition extending into a bath of mercury. The mercury may be connected directly as a cathode, or in certain rare instances it may serve as a pair of electrodes. In this case the electrodes which are connected to the source of energy are suspended above the mercury, one on each side of the partition, the mercury in the positive side becoming negative, and in the negative compartment becoming positive.

A third type of compartment cell is one in which the electrodes are separated by a partition which extends below them, but which does not touch the bottom of the cell. Gaseous products, such as oxygen and hydrogen may in this manner be kept separate, or one gaseous product may be removed and a product from the other electrode allowed to remain, either in solution, or as a precipitate.

It will be obvious that the principle of electrolysis mentioned above holds for all classes of cells. Different designs are only for purposes of convenience, economy, and for taking advantage of the fact that at a given moment two components of a compound are chemically free and separated from each other mechanically.

After one has become familiar with the general principles of electrolysis and has personally observed the phenomena of such cells as he may construct, the various texts on the subject will be read with great interest and profit. To the investigator who is not of a mathematical turn, it is suggested that he get what he can out of these books which come under his observation in which mathematical expressions are frequent. It is a very rare thing indeed that an author succeeds in concealing all of his thoughts from the fellow who is after facts.

### The Electric Furnace

In the broadest sense, the electric furnace is an apparatus for the transformation of electrical energy into heat and applying this heat directly as desired. The heat is always obtained by the introduction of resistance to the passage of the current. This resistance is always in the furnace itself and may be obtained in a large number of ways, depending upon the effect desired.

No experimenter who may have occasion to attempt electric furnace investigation should be without a good descriptive text such as Stansfield or Blount.

The construction of an electric furnace is a very simple matter. The first experiments will usually be of a qualitative nature, and experience will indicate changes after each furnace operation which will require different shapes and sizes of crucible, different placing of electrodes, and different manner of lining. Build the furnace as easily and quickly as possible at first and do not worry over losing a little heat. There is a special economic law allowing quite large losses in experimental work.

### Qualitative Experiments

It is a waste of time in the beginning to calculate and weigh slag components and reducing agents too closely. Since the dust and gas losses, amount of lining chewed up by the slag, the action of the bath on the electrodes, etc., are not known, more can be learned by a few trial heats than by much calculation.

It is also a waste of time to worry over the chemical constitution of compounds which are to be smelted. It is a safe rule to follow that the electric furnace will reduce the various oxides to a common denominator in a short time. The thing to know is the oxygen content, the base metal content, and about what sort of slag the impurities will form. It makes no difference whether the iron oxide is combined with the alumina, the silica, or both, so long as the ultimate analysis is known.

### Interpretation of Results

Accurate notes should be kept of all important matters, such as quantities, time, instrument readings, etc., but they usually have no direct meaning. There is almost nothing in the first stages of any kind of experimental work which does not have to be interpreted. The fact that one uses two pounds of electrode for each ounce of metal produced has but little bearing on the problem as a whole. In technical journals and society transactions we sometimes read very painstaking reports of experiments, giving electrical efficiencies, recoveries, electrode losses per pound (or per gram), and in fact drawing supposed conclusions of commercial practice from the data per se. The results of the small experiment are of value only if understood.

### Power Supply and Apparatus

Some who may wish to attack a problem by using electrical energy, may be held back by the fact of having no available supply of power suited to their requirements. To these I suggest a conference with the local manager of the power company, and failing to get him interested, a meeting with the head officials will get results. It is known that experiments with electric furnaces and electrolytic cells lead to the consumption of power, and I have never met with a power company which would not meet me more than half way in developing new demands for their product.

One may borrow old transformers, or rent a secondhand generator. I once bought an old transformer core for $4.90; an additional $20 paid for the copper windings and small incidentals, so that the complete transformer cost about $25. I could obtain as high as 30 kw for an hour or so and 20 kw continuously.

An electric furnace may with economy replace gas or coke furnaces in many instances. For example, a cyanide mill may be somewhat remote from the railroad, but may have electric power. Instead of hauling gasoline for refining, it would be a very simple matter to construct a small electric furnace holding a No. 60 crucible, and the cost of operation would be very small. In fact, the losses attendant upon working around the usual coke or gasoline furnace would more than offset any difference in cost. When using a coke-fired furnace the gold is refined by a man who has to protect himself from the heat with an asbestos face mask and a suitable shield for his body. One may work with an electric furnace at 1200 deg. C. with bare hands.

I believe an electric furnace will be devised which will enable zinc smelters to redistill blue powder and dross much more efficiently than in the retort. It has been recently said that the trouble with electric zinc smelting processes usually was that the inventor endeavored to cause the zinc vapor to go in one direction and the gases of combustion in another. The writer of the article was of the opinion that this was an obvious impossibility. I am not so sure about it; in fact I rather expect that furnaces will be devised which will do this very thing.

### The Economic Phase

While attacking a problem of ore treatment with purely mechanical means, hydrometallurgical methods, electrolysis, or smelting (electric or otherwise), the economic phase must not be lost sight of. Unfortunately, no rule can be formulated giving limits between which a profitable cost of treatment might lie. This is because there are very few, if any, standard methods of treatment which will deliver a metal or other product at a cost which bears a fixed relation to the selling price.

There are, however, certain factors which may be calculated with some accuracy in each specific case, which when given their approximate cost value, will permit of a reasonable deduction being made from the gross value of the ore. These factors, among which are cost of mining, crushing, interest, depreciation, maintenance of laboratory, and allowance for actual recovery (60 per cent, 70 per cent, 80 per cent, as the case may be), can be determined with reasonable accuracy by reference to published data on costs of standard operations.

It will then appear that an ore which has a gross value of $20 per ton will have a value of somewhat less after making a fair deduction representing costs up to the process proper as suggested above. There will also be a shrinkage of values on the other end, such as transportation, penalties, smelting charges, etc., all of which lie between the material as produced and its market value in a finished condition.

Between the limits imposed by the shrinkages as set forth there lies a domain of values which is affected by the process itself. Here may be found the profits if the process is not too expensive.

As a corollary it may be said that the more standard operations one can employ in devising a process, the more accurate will be his cost estimates.

In conclusion, I wish to call attention to the fact that I have tried to deal solely with generalities, using specific instances only as illustrations and not in any sense as descriptions. I have endeavored to state facts and opinions in such a manner as not to give offense to specialists, and although there is an obvious appeal to research men for discussion and other angles on experimental work, there is implied no challenge.

I owe much to Mr. Arnold J. Guerber, chief chemist of the Standard Chemical Company, who has made many criticisms and suggestions.

Canonsburg, Pa.

## Electrolysis of Fused Materials Containing Zinc

"The Electrolysis of Fused Material Containing Zinc" is the title of a paper by Mr. Chun Hao Wang presented as a thesis for the degree of Doctor of Philosophy at Columbia University. The investigation was carried out at the Columbia School of Mines under the direction of Professor Edward F. Kern.

The first part of the paper is a review of existing literature on the electrolysis of aqueous zinc salt solutions, the precipitation of zinc from fuse baths, and the electrothermal treatment of zinc ores. Mr. Wang points out that before the electrolysis of fused zinc electrolytes can be carried on to advantage, there must be found a salt or a mixture of salts which is fusible at a temperature below the boiling point of zinc (920° C.), which is a good solvent for zinc sulphide or zinc oxide, and which will not volatilize at the temperature at which the electrolysis must be conducted.

In order to obtain these data the following experiments were conducted by the author:

1. Determination of the freezing points of several salts and mixture of the same.
2. Determination of the solubility of zinc sulphide and of zinc oxide in the salts, and in the mixtures, whose freezing points were determined, and the freezing point of the resulting fused solution.
3. Electrolysis of the fused solutions of zinc sulphide and of zinc oxide, finally selecting that bath which gives the most promise for the recovery of zinc from zinc sulphide, or from zinc oxide, by electrolysis.

The results of the experimental works on freezing points and solubility may be summed up as follows:

Sodium hydroxide freezes at 312° C. The addition of sodium tri-sulphide (freezing point 650° C.) up to 35 per cent causes a rapid rise of the freezing point. Above 35 per cent of sodium tri-sulphide the mixture solidifies in two layers.

Sodium tri-sulphide and mixtures of sodium tri-sulphide and hydroxide, are good solvents for zinc sulphide and zinc oxide (2 to 7 per cent zinc).

Calcium chloride freezes at 744° C. The addition of sodium hydroxide causes a reduction of the freezing point, which is intermediate of the freezing points of the components of the mixture.

Zinc oxide and zinc sulphide are soluble in calcium chloride and in mixtures of calcium chloride and sodium hydroxide only to a small extent (below 0.7 per cent zinc).

Sodium thiosulphate freezes at 804° C., dissolving over 1 per cent zinc either as zinc sulphide or zinc oxide.

Sodium silicates: Sodium bisilicate freezes at 1002° C. The increase of base up to 57 per cent, corresponding to sodium sesquisilicate, causes a decrease in the freezing point to 950° C. The further increase of the base up to 67 per cent, corresponding to sodium monosilicate, raises the freezing point. Sodium monosilicate solidifies at 1025° C.

Undercooling occurs with sodium silicates which have a silicate degree varying between the bisilicate and monosilicate. Undercooling is prevented by stirring the cooling mass.

The formation temperature of sesqui-sodium-silicate from a mixture of three molecular equivalents of sodium carbonate, and one molecular equivalent of silica is about 1200° C., whereas the freezing point of this silicate was found to be 800° C.

Boric anhydride in certain proportions causes the reduction of the freezing points of sodium silicates. An excess, in the case of the silicates containing more than 40 per cent of silica, causes the mixture to become mushy. The addition of zinc oxide to sodium silicates containing about 25 per cent boric anhydride raises the freezing point of the mixture.

Calcium fluoride lowers the freezing point of sodium silicates, producing a thinner fusion. The addition of zinc oxide to these mixtures containing 10 to 22 per cent calcium fluoride hastens the solidification of the resulting mixture.

The author's experiments on the recovery of zinc by electrolysis of fused solutions may be summed up as follows:

The zinc which was liberated by electrolysis is of fused sodium silicate, and sodium tri-sulphide baths collected as pellets, which remained in suspension in the fused electrolyte.

A bath of sodium bisilicate containing 25 per cent of boric anhydride, 22 per cent of calcium fluoride and zinc oxide (2.3 per cent zinc) after electrolysis showed a loss in the weight of the zinc bottom which was added at the start.

A bath of sodium monosilicate containing 20 per cent of boric anhydride and saturated with zinc oxide (5.8 per cent of zinc) showed great corrosion at the anode. In one case 32 grams of deposited zinc were collected by the metallic bottom (current efficiency 14.7 per cent), while in the other runs there was neither loss nor gain in weight of the bottom. Zinc flame was liberated around the cathode surface. The zinc was found in the cold solid bath as disseminated pellets.

Reversing the current for a short period previous to the electrolysis was found to be beneficial in electrolyzing fused electrolytes containing zinc.

The electrical conductivity of the fused sodium silicate baths containing boric anhydride increases with the decrease of the silicate of the mixture.

Fused baths composed of sodium hydroxide and sodium tri-sulphide containing zinc sulphide have higher electric conductivity than the fused sodium silicate electrolytes containing zinc oxide.

Sodium tri-sulphide baths containing zinc sulphide (5.8 per cent zinc) gave a very thick layer at the bottom which, however, was rendered fluid by adding lumps of sulphur.

The zinc liberated from fused baths of either sodium silicate or sodium tri-sulphide, saturated with zinc, does not collect as a mass on the cathode, but as pellets, which are mechanically carried into the fused electrolyte and held in suspension. This was also found by Thomas and others to take place in their fused zinc baths, which they attributed to be due to the formation of colloidal zinc, or zinc mist at the cathode. This, however, may be due to the high surface tension of zinc at temperatures near its boiling point.

The low efficiency of electrolysis of fused baths containing zinc is due to the zinc forming as pellets on the cathode, which are carried back to the anode and there oxidized and redissolved. Another cause of low efficiency is the loss of zinc partly by volatilization, due to the high current density at the cathode, the temperature at the surface of the cathode being higher than that of the bath.

By surrounding the cathode by means of a refractory condenser, the electrolysis of fused zinc electrolytes may be conducted at temperatures above the boiling point of zinc, collecting the deposited zinc in the condenser.

## The Determination of Phosphorus in Phosphor-Bronze

BY E. W. HAGMAIER

Phosphor-bronze is one alloy of which the chemist cannot say much as to phosphorus content until he has obtained the precipitate of phosphorus. Alloys called phosphor-bronze may contain anywhere from zero to 1 per cent or more of phosphorus. An experienced analyst may get somewhat of an idea as to whether the phosphorus is high or not by observing the condition of the metastannic acid in dilute nitric solution. If the phosphorus is ½ per cent or so, the metastannic acid will keep the original form of the drillings, after the copper, lead, etc., have gone into solution. The metastannic acid will be a grayish black when on the filter paper.

The writer has had occasion to analyze numerous phosphorus alloys in the last year and a half, and while doing so worked out an accurate and rapid method which will follow after a brief review of some of the older methods.

One method which is used a great deal is as follows: Dissolve one gram of the alloy in 30 c.c. of (1-1) nitric acid, and evaporate to a paste. Take up with a little dilute nitric and hot water, and boil to dissolve the copper, lead, etc., which has separated out. Remove from the hot plate and filter. The phosphorus is with the metastannic acid, provided there is sufficient tin present. The writer's experience has been that 6 per cent to 8 per cent of tin will hold up over 1 per cent of phosphorus. This precipitate is ignited in a tarred porcelain crucible, and the weight of the combined oxides of tin and phosphorus recorded. Potassium cyanide is then added to the crucible, and a fusion made. This converts the tin to metallic tin, and the phosphorus to potassium phosphate. The melt is then leached out with water, and the tin filtered off. The filtrate is made acid with nitric acid and boiled to drive off the cyanide. After all is driven off filter off any silica which may have come from the fusion attacking the crucible. The phosphorus is then precipitated in the usual way, and is determined and calculated to phosphorus pentoxide. This weight is deducted from the weight of the combined oxides already found, and the tin calculated.

This method will require at least two and one-half hours to get the phosphorus precipitated. It is necessary to run a blank on the potassium cyanide unless a special phosphorus-free cyanide is used. The amount of tin must always be sufficient to hold up all the phosphorus; that is, 6 per cent to 8 per cent of tin for 1 per cent of phosphorus, otherwise it is necessary to add sufficient tin or some of the phosphorus will go in the filtrate with the copper, lead, etc.

Another method quite frequently used is to make a sodium carbonate and sulphur fusion of the combined oxides of tin and phosphorus, leach out with water, and filter off any sulphide of copper which may have been held with the tin. Make the filtrate slightly acid with hydrochloric acid, and filter off the sulphide of tin, boil off excess hydrogen sulphide, add nitric acid, evaporate to a low bulk, cool, add excess ammonia, then nitric acid, and precipitate the phosphorus.

This method is by no means shorter than the previous one, and it is next to impossible to wash the sulphide precipitates free from phosphorus.

A modification of the previous method is used by some chemists. An aquia regia solution of the alloy is made, excess ammonia added, and the solution saturated with hydrogen sulphide. The sulphides of copper and lead are filtered off, then the filtrate is made acid with hydrochloric acid, and the tin sulphide removed. The phosphorus is then determined in this filtrate.

This method is the least satisfactory of any. It is next to impossible to wash the phosphorus out of the sulphide precipitates.

One can readily see that the foregoing methods are long and rather objectionable. With the idea of saving time and at the same time increasing the accuracy the writer conceived the idea of using cerium chloride as a precipitant for the phosphorus, similar to the one suggested by him for the determination of phosphorus in vanadium steels. (This journal, January, 1913.)

The method used is as follows: Dissolve one gram of the bronze in 10 c.c. conc. hydrochloric acid and 5 c.c. conc. nitric acid in a tall-form 300 c.c. beaker. When solution is complete, add 150 c.c. of hot water, and 10 c.c. of a solution of cerium chloride (1 gram cerium chloride, 25 c.c. hydrochloric acid, 200 c.c. water). Now add a solution of one part ammonium hydroxide and two parts water, from a burrette, stirring continually until the solution has a greenish blue cast. This will require from 25 c.c. to 35 c.c. Now add 4 c.c. of acetic acid, and boil for five or ten minutes; remove from the hot plate and allow the precipitate to settle; this will require several minutes. Syphon off as much of the clear solution as possible, add 100 c.c. of hot water and again syphon. Repeat this washing six or eight times; with careful manipulation all but about 30 c.c. of the liquid can be decanted each time without disturbing the precipitate. After sufficient washing add 15 c.c. of nitric acid and 3 c.c. of hydrochloric acid

TABLE I

| Phosphorus added. | Phosphorus found. |
|---|---|
| .10% | .084 |
| .10% | .089 |
| .10% | .105 |
| .20% | .208 |
| .20% | .192 |
| .20% | .189 |
| .30% | .306 |
| .30% | .297 |
| .50% | .509 |
| .50% | .492 |
| .50% | .496 |
| .50% | .490 |
| .70% | .711 |
| .70% | .693 |
| .80% | .806 |
| .80% | .792 |
| 1.00% | .997 |
| 1.00% | .984 |
| 1.00% | 1.008 |
| 1.00% | .990 |

ACTUAL PHOSPHOR-BRONZES

| Average of five analyses. | Cerium Chloride. |
|---|---|
| .068% | .061 |
| | .065 |
| | .069 |
| | .070 |
| .78% | .765 |
| | .790 |
| | .788 |
| | .774 |
| .79% | .796 |
| | .793 |
| | .791 |
| .65% | .664 |
| | .672 |
| | .659 |
| .813% | .822 |
| | .827 |
| | .818 |

Babcock-Hagmaier Laboratories,
Lackawanna, N. Y

and heat until the precipitate has all dissolved. When solution is complete, cool, add 5 c.c. (1-1) ammonia, and precipitate the phosphorus.

By this method the writer has been able to have the phosphorus precipitated in duplicate on three samples in an hour. When this method is used the tin is determined on a separate sample either electrolytic, by titration, or from the combined oxides.

The following results were obtained on actual phosphorus-bronzes, and on bronzes to which a known amount of phosphorus was added.

---

## The Emissivity of Metals and Oxides

### I.—Nickel Oxide (NiO) in the Range 609 to 1300 C.*

BY G. K. BURGESS AND P. D. FOOTE

The object of the present investigation has been the determination of the monochromatic emissivity $E_\lambda$ and total emissivity E of nickel oxide NiO in the range 600 deg. C. to 1300 deg. C. This oxide forms a tough, smooth layer on the surface of nickel when subjected to high temperatures in air. Two methods were employed for the determination of the emissivity for red light: (a) that of microscopic melts and (b) a direct comparison by a spectrophotometer of the intensity of light emitted by the glowing NiO and by a black body at the same temperature.

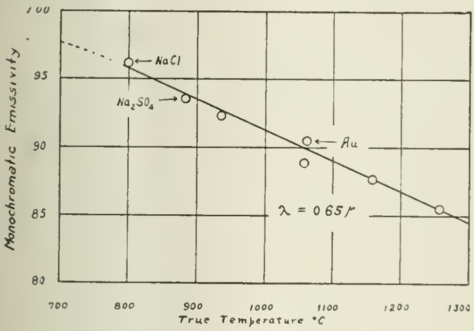


FIG. 1—MONOCHROMATIC EMISSIVITY ($\lambda = 0.65 \mu$) VS. TEMPERATURE

In the method of microscopic melts, minute specimens of NaCl, $Na_2SO_4$, and Au were placed on the oxide which was electrically heated until these substances melted, as observed with a microscope, and the "apparent" temperatures at the instant of melting were measured by an optical pyrometer. The relation between the true temperature of the oxide, the observed or apparent temperature, and the emissivity is expressed by:

$$\frac{1}{T} - \frac{1}{S_\lambda} = \frac{\lambda}{0.4343\, C_2} \log A_\lambda$$

where $T$ is the true absolute temperature, $S_\lambda$ the observed absolute black body temperature for a wave length λ, $c_2$ the Planck or Wien constant (14,450) and $A_\lambda$ the emissivity for a wave length λ.

In the spectrophotometric method, a nickel strip was folded, forming a wedge or V-shaped cavity, and electrically heated until a coat of the oxide was formed. It has been shown by Mendenhall that the radiation from the interior of a V-shaped cavity is closely "black." The ratio of the intensities of the outside and inside of the wedge, properly corrected for temperature gradient through the walls, gives at once the emissivity at any particular wave length and temperature. Determinations by this method agree with those by the method of microscopic melts, as is seen in Fig. 1. This curve represents the monochromatic emissivity, for $\lambda = 0.65 \mu$, as a function of the temperature. Over the range 700 deg. t o1300 deg. C., the emissivity decreases with increasing temperature.

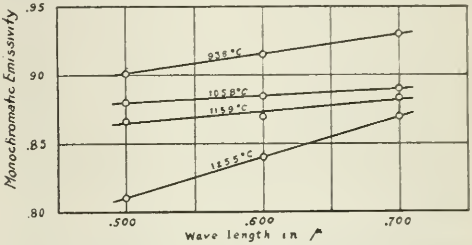


FIG. 2—MONOCHROMATIC EMISSIVITY VS. WAVE LENGTH

Fig. 2 shows the dispersion of the emissivity of NiO in the range $\lambda = 0.5$ to $0.7 \mu$ for the temperatures 938, 1058, 1159 and 1255 deg. C. Over this range of the spectrum the emissivity is found to increase with increasing wave length. The type of curves suggests the presence of an absorption band in the early infra-red, but one which is probably broad and not well defined.

The total radiation of NiO was investigated by means of twelve radiation pyrometers of the Thwing and Féry types. These instruments were sighted upon a strip of the electrically heated oxide. The apparent temperatures of the oxide for $\lambda = 0.65 \mu$ were measured by a Holborn-Kurlbaum pyrometer and these values corrected to true temperatures by means of the determinations on the monochromatic emissivity. Knowing the apparent absolute temperature, S. determined by the

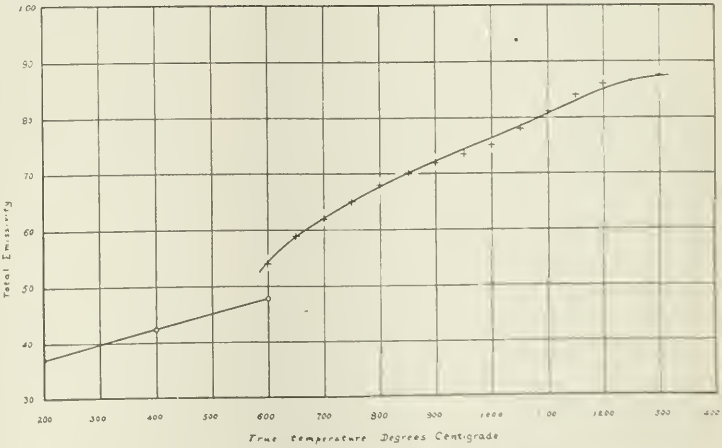


FIG. 3—TOTAL EMISSIVITY VS. TEMPERATURE

---

*The complete paper giving all observations and detailed description of apparatus will appear in the Bulletin of the Bureau of Standards.

radiation pyrometers, and the true absolute temperature, $T$, the total emissivity, $E$, may be computed from the relation $E = \frac{S^4 - T_0^4}{T^4 - T_0^4}$, where $T_0$ is the absolute temperature of the receiver.

Fig. 3 represents the total emissivity as a function of the temperature. The increase of emissivity with increasing temperature is very pronounced. In the range 700 deg. to 1200 deg. the increase is nearly linear with temperature. Obviously, this linear relation will not extend indefinitely, for the emissivity can not exceed 1.00 or become zero. The characteristic curve must therefore be bent at both ends. This departure from the straight line is apparent at 1200 deg. to 1300 deg. It is possible that the emissivity at still higher temperatures increases very slightly and gradually until the melting of the oxide may bring about a discontinuity in the curve. Somewhere below 600 deg. the curve must again change its slope, possibly becoming approximately parallel to the axis of temperatures.

The three points represented in Fig. 3 by circles are from the data of Randolph and Overholser. It is possible to extend our curve so that it will coincide with the 400 deg. and 200 deg. points determined by these investigators. The disagreement of the two curves at 600 deg., however, would indicate a systematic difference between the two sets of data.

The following table gives the true temperatures corresponding to the temperatures observed by (1) an optical pyrometer using red right ($\lambda = 0.65\,\mu$) and (2) by a total radiation pyrometer when sighted on nickel oxide.

| Observed temperature deg. C. | Optical pyrometer true temperature deg. C. | Radiation pyrometer true temperature deg. C. |
|---|---|---|
| 600 | ... | 710 |
| 700 | 701 | 800 |
| 800 | 802 | 895 |
| 900 | 904 | 985 |
| 1000 | 1007 | 1075 |
| 1100 | 1110 | 1165 |
| 1200 | 1215 | 1255 |
| 1300 | 1320 | 1350 |

Bureau of Standards, Washington, D. C.

## Energy of Vaporization of Carbon

BY CARL HERING

The energy required to vaporize carbon, commonly called the latent "heat" of vaporization, does not seem to have been determined experimentally. It is sometimes very desirable to know it in analyzing the energy reactions in electric furnace processes, in which the cost of the energy is often an item of importance. One therefore has to resort to the less satisfactory method of determining it by calculation, at least approximately. The following is an attempt to do so on a basis which may possibly be new:

According to experimental determinations the energy set free when one gram molecule (28 grams) of CO is formed from one gram atom (12 grams) of solid C and one gram atom (16 grams) of gaseous O, is given in books as 26.1 kilogram calories. When one gram molecule (44 grams) of $CO_2$ is formed from solid C and gaseous O, the energy set free is stated to be 94.3 kg cal. When one gram molecule of gaseous CO is burned to gaseous $CO_2$, 68.2 kg cal are set free, this being of course equal to the difference between the other two, 94.3 — 26.1.

When solid carbon is changed into a gas, then the attraction of the molecules of the carbon which caused it to be a solid, has been overcome and the molecules have been separated far enough to make it a gas; this is true whether this gas is a true vapor of carbon or a gaseous compound of carbon. It takes energy to do this, and the amount required for the true vapor is usually termed the heat of vaporization. There seems to be no good reason why this should be materially different in amount when the gas is a compound of carbon like CO or $CO_2$ than when it is the pure vapor; the disruption of the molecules from each other is accomplished in either case. Let this energy be represented by $V$ in kg cal for the amount of carbon now involved, namely, 12 grams.

The energy for this physical change of state must have been supplied by the energy of the chemical union of solid C and gaseous O, hence the observed 26.1 effective kg cal of their union to CO is only the difference between the purely chemical energy and what might be called the purely physical energy. The real chemical energy is therefore $26.1 + V$. Similarly the real chemical energy of $C + O_2 = CO_2$ is $94.3 + V$. When CO is burned to $CO_2$ no energy of vaporization is involved, all the components being gases before and after the reaction. The energy involved in changes of volume against atmospheric pressure, may be neglected in the present discussion as being relatively quite small; moreover, it is often considered to be included in the figures for the latent heats.

These two numerical values together with $CO + O = CO_2 = 68.21$, are not sufficient to calculate $V$ from them. Prof. J. W. Richards in the *Trans. Amer. Electrochem. Soc.*, Vol. XIII, p. 451, estimates the latent heat of vaporization of carbon by calculation based on Trouton's statements, to be approximately 3808 calories per kilogram. But, like many other authors, he unfortunately omits stating whether these are large or small calories; there is no doubt, however, that kilogram calories were meant.

For the 12 grams of carbon now involved, the volatilization energy $V$, required in the combustion, would then be 45.7 kg cal. Hence the real chemical energy of $C + O = CO$ would be $26.1 + 45.7 = 71.8$; and of $C + O_2 = CO_2$, $94.3 + 45.7 = 140.0$. It will be noticed that when thus reduced to true chemical energies, the latter is almost exactly double the former, and the former is very nearly the same as the 68.2 for $CO + O = CO_2$. Changing the volatilization energy from 45.7 to 42.1 (only about 9 per cent) makes this relation exact; the true chemical energy of CO would then be 68.2, which is the same as found for CO + O; and that of $CO_2$ would be 136.4, which is exactly double 68.2.

While such an agreement may, of course, be merely a coincidence of no significance, yet on the other hand there is a good reason to believe that it should be so, as it would simply mean that, when reduced to *true* chemical energy, carbon develops exactly as much energy in combining with its first molecule of oxygen as it does in combining with the second one, and this would by no means be unlikely or irrational, but is even likely to be the case.

If the latter is true, then it becomes possible to deduce the true energy of vaporization of solid carbon very simply and directly from these two observed physical constants 26.1 and 94.3, in the way explained above. That for 12 grams then being 42.1 kg cal, the specific value would be 3510 kg cal per kg. This is only about 9 per cent less than Prof. Richards' calculated value 3808, which he himself gives only as an approximation. Berthelot, in his well-known treatise, does not give any definite value for the vaporization energy of carbon, but he states with positiveness that it is not less than 42.1 kg cal for 12 gr.; this is exactly the same figure as that given above.

Working backwards from this value by the same method as used by Prof. Richards to deduce it, brings the boiling point of carbon (namely, the temperature of the arc) down to 3387° C., which seems to agree even better with other determinations than the value assumed by him, 3700° C.

To further investigate whether it is a mere coincidence or whether it is likely to be a possible law, that the true chemical energy of each bond between like elements is the same, the writer has in the accompanying table deduced the true chemical energy between the bonds of carbon and hydrogen, as the known compounds formed between these two elements are far more numerous than between carbon and oxygen. Those here given are only those which normally are gases, so as to eliminate the unknown physical energies which must be set free when gaseous hydrogen contracts in forming liquid or solid compounds. They are furthermore limited to those whose energies of combinations have been determined by experiment, or possibly only by calculation, and have been published. In the formation of all of these compounds it is here assumed (although not always so stated in the books) that the original materials were solid carbon and gaseous hydrogen, hence that a physical change from solid carbon to a gaseous compound is involved in the reaction. The so-called "heats" of combination on which the present deductions are based, are probably not accurate and may in some cases even be quite inaccurate, more especially in the more complex quantities toward the bottom of the table; hence very close agreement cannot be expected in such an analysis as this.

These fourteen different compounds of C and H are arranged in this table in the order of the number of their atoms of carbon and hydrogen. The first column gives their molecular formula (which in some of the more complex cases may perhaps not be definitely known). The second column gives the energies of their formation from solid carbon and gaseous hydrogen, as given in reference books; the numbers in all the other columns except the last, have been deduced by the writer. The + and — signs mean energies set free or consumed, respectively.

The third column gives the physical energies consumed in the vaporization of the carbon, using the basic figure deduced above, namely, 42.1 kg cal per gram molecule (12 grams) of carbon. This is the only physical change considered for the first approximation. The important point at present is not so much the actual value of this constant, as the fact that it is taken to be the same for all.

The next column shows what the purely chemical energy must have been so as to have furnished the physical energy in the previous column, and the net balance given in the second column; these net balances are the algebraic sums of the figures in the third and fourth columns.

Having thus determined the first approximation to the true chemical energy, these numbers are then divided by the number of hydrogen atoms to see whether the energy value for each hydrogen atom is the same in the different compounds. These results are given in the fifth column, and it will be noticed that, at least for the simpler and better known compounds, there is a rather surprisingly close agreement, considering the crudity of the basic data and the following additional correction factors.

It will be noticed that the energy per H atom thus deduced grows larger as the number of atoms of carbon in the molecule increases; also, in each group, as the number of hydrogen atoms per molecule increases; hence it would be natural to suppose that it might increase as their product. This increase is as would be expected. More atoms are crowded into a molecule in the more complex materials. Such more crowded molecules mean physically that either there has been less expansion of the solid, or some contraction of the gas, or both; either means a gain of energy (physical). These gains mean that the physical energies in the third column are numerically less, and that the calculated, purely chemical energies are therefore less than those given in the first approximation in the fourth column.

TABLE.

| I | II | III | IV | V | VI | VII | VIII |
|---|---|---|---|---|---|---|---|
| | Kilogram Calories | | | | | | |
| | Per gram molecule | | | Chemical per H Atom | Molecular per Gr. Mol *e* | Second Approx Col V | Combustion Energy per Gr. Mol. |
| | Net | Physical | Chemical | | | | |
| $CH_4$ | +18.9 | − 42.1 | + 61.0 | +15.25 | 0 | +14.25 | 213.5 |
| $C_2H_2$ | −51.4 | −84.2 | + 32.8 | +16.4 | + 2.3 | +14.4 | 313.8 |
| $C_2H_4$ | −14.6 | −84.2 | + 69.6 | +17.4 | + 8.6 | +15.4 | 341.1 |
| $C_2H_6$ | +23.3 | −84.2 | +107.5 | +17.9 | + 16.0 | +15.9 | 372.3 |
| $C_3H_4$ | −52.6 | −126.3 | + 73.7 | +18.4 | +12.7 | +15.4 | 473.0 |
| $C_3H_6$ | −17.1 | −126.3 | +109.2 | +18.2 | + 17.7 | +15.2 | 507.0 |
| $C_3H_6$ | − 9.4 | −126.3 | +116.9 | +19.5 | + 25.4 | +16.4 | 499.3 |
| $C_3H_8$ | +30.5 | −126.3 | +156.8 | +19.6 | + 31.8 | +16.6 | 528.4 |
| $C_4H_8$ | + 2.6 | −168.4 | +171.0 | +21.4 | + 49.0 | +17.3 | 650.2 |
| $C_4H_{10}$ | +35.0 | −168.4 | +203.4 | +20.3 | + 50.9 | +16.3 | 687.2 |
| $C_5H_{10}$ | + 7.3 | −210.5 | +217.8 | +21.8 | + 65.3 | +16.8 | 804.0 |
| $C_6H_6$ | −11.3 | −252.6 | +241.3 | +40.2 | +149.8 | +34.2 | 784.1 |
| $C_7H_8$ | − 5.4 | −294.7 | +289.3 | +36.2 | +127.3 | +29.3 | 933.8 |
| $C_8H_{10}$ | − 6.8 | −336.8 | +330.0 | +33.0 | +177.5 | +25.0 | 1084.3 |
| $C_{10}H_{16}$ | +12.2 | −421.0 | +433.2 | +27.1 | +189.2 | +17.1 | 1473.3 |

For the present purpose of analyzing the energy reactions only, it may be assumed that all the atoms of carbon were first separated by the energy represented by the latent heat of vaporization (third column) and then afterwards compressed or condensed again to the extent represented by the molecular formula in the first column; also that the hydrogen atoms, originally fully separated, have also been condensed to the indicated extent. Such condensations or contractions are exothermic; that is, they set free energy, and this energy, it is not unreasonable to suppose, should be greater the greater this condensation (which it will be seen from the table is the case), but according to what quantitative law is perhaps not yet known.

The sixth column shows what this physical energy of molecular condensation *e* would have to be in kg cal per gram molecule of the compound if the law above suggested is true, namely, that the true chemical energy (when separated from all the energy of physical changes) is a constant for each hydrogen atom with which the carbon has combined. If these energies could be calculated or measured, and were found to agree approximately with those in this column, it would establish this proposition and at the same time confirm the value for the energy of vaporization of carbon assumed in this analysis. The first value in the fifth column (+ 15.25) has in this first approximation been taken as a basis for calculating *e* because that compound contains the least carbon per molecule.

It will be noticed that the values of this extra energy *e* increase approximately in proportion to the product of the number of atoms of carbon and of hydrogen. This may again be a mere coincidence, but both the direction and the relative amounts are what one might expect, and that some energy would be set free by increasing the number of atoms in a molecule will probably not be questioned; it is claimed, for instance, that carbon vapor has double the latent heat of vaporization when monatomic than when diatomic.

Adjusting the purely chemical energies in accordance with this proposition concerning the energy *e*, gives as a second approximation for the hydrogen bond the figures in the seventh column, which it will be seen are in rather strikingly close agreement, excepting only some of the more complex molecules the constitution of which may perhaps not yet be definitely known. The agreement is now far better than in the fifth column.

In a further approximation the values of *e* should be added algebraically to the physical energy in the third column, in order to give the total physical energy involved; and they should also be subtracted arithmetically from the chemical energy in the fourth column, to give the true chemical energy; the algebraic sum of these new physical and chemical energies will then again give the observed net values in the second column.

It may or may not be a further coincidence that the purely chemical bond of oxygen is nearly the same for the combination with carbon as with hydrogen.

As a matter of interest the energies of combustion (presumably into $CO_2$ and $H_2O$, although not always so stated in books) are added in the final column. It will be noticed, and this may also be of significance, that when these compounds are arranged in this order, as distinguished from the order more generally used in books, they are also in the order of their combustion energy value, the only exception being again $C_6H_6$ (benzol) which is out of agreement in other columns also, hence is likely to be wrong; and either one of the two values of $C_3H_6$ (propylen and trimethylen), which, disagreeing with each other, cannot both be correct.

The above analysis is an illustration of the possible importance of more clearly distinguishing between the purely physical and the purely chemical reactions in energy equations, as was advocated in an article on this subject by the writer in the July issue of this journal, page 439.

The writer is indebted to Prof. G. A. Roush for some information concerning existing and non-existing data.

Philadelphia, Pa.

## Recent Chemical and Metallurgical Patents

### Iron and Steel

**Electric Steel.**—To Mr. **William R. Walker**, of the United States Steel Corporation, recently two interesting patents have been granted on electric steel processes.

The first patent relates to the manufacture of steel from iron which may be classified as to its phosphorus content between the grades commonly known as basic Bessemer iron (1.8 to 2.2%, P) and acid Bessemer iron (below 0.12%, P). The iron is first blown in acid converters of 13 tons capacity to remove the silicon and a portion of the carbon. The iron is only slightly oxidized by this partial blow. It is then transferred to an intermediate mixer of 125 tons capacity in form of a basic open-hearth furnace, so as to bring about substantial uniformity in the products of the several converters and to carry always a supply of hot metal for the subsequent treatment in the electric furnaces. In the mixer the phosphorus content is reduced to the point desired in the final product, while a portion of sulphur is incidentally removed and more iron is oxidized. From time to time portions of metal in the intermediate mixer are transferred to acid-lined electric furnaces of 25 tons capacity where the metal is deoxidized. The metal is then transferred to a final mixer in form of a ladle of 100 tons capacity with an acid lining and with or without electrodes or other heating means. A substantial quantity of molten metal is maintained in this final mixer so as to obtain a product uniform in carbon and other ingredients. The refined steel produced in this final mixer is then cast either directly therefrom or by transferring it first to a more convenient smaller casting ladle. Either in the electric furnace or in the final mixer or in both, deoxidizing additions of manganese and aluminium are made to the metal. The chief feature of this combination process is that the cost of the electric furnace treatment is considerably reduced. Not only does the intermediate mixer provide metal for a nearly continuous use of the electric furnaces but the cost of dephosporization in the mixer is low. The electric furnace is used for nothing but deoxidation for which purpose it is eminently fitted on account of its reducing atmosphere. Finally the use of an acid electric furnace means a substantial saving of expense, both first cost and repairs and other operating costs, and a larger tonnage per day than could be obtained with a basic lining. (1,086,003, Feb. 3, 1914.)

In Mr. Walker's second patent, which refers to basic-lined electric furnaces, it is pointed out that the object for using a highly basic slag in electric steel furnaces is to reduce to a minimum the sulphur content of the product. He has found, however, that by using a slag containing a comparatively high percentage of silica, the sulphur content may be reduced to practically the same extent as before and considerable economies are effected in the operation of the furnace and also an improvement obtained in the quality of the steel. Mr. Walker proposes to increase the quantity of silica in the slag in basic processes to such an extent that a part will be reduced and remain in the metal, at the same time keeping the percentage of silica so low that it will not cut the hearth to any substantial extent. As a good practical example is cited a slag made of silica 30 per cent and lime (approximately pure Ca O) 70 per cent, to which is added coke at least 5 per cent by weight of the combined silica and lime. This slag will also contain magnesia and alumina, which are derived from the furnace bottom materials and the lime additions. The process has various advantages. Slag of this composition is more fusible. The quantity of fluorspar may be reduced to little or none. The formation of fumes in the furnace is minimized. The silica roof of the furnace will last much longer. The process is of particular advantage in the manufacture of soft steel. The greater or less quantity of nascent silicon which enters the bath serves to purify it and in a way to make up in purifying effect for the lack of carbon in the bath. The silica in the slag may be so proportioned that the quantity of nascent silicon which enters the bath shall be only sufficient to have a purifying effect and shall not be sufficient to leave any appreciable percentage of silicon in the finished product. (1,086,489, Feb. 10, 1914.)

**Manufacture of Electrolytic Iron.**—To obtain high efficiency in the electrolytic production of iron deposits, **Anthelme Boucher** suggests the use of a high-current density. Ferrous salts may be used as electrolyte and to obtain a smooth surface, the electrolyte is stirred with air, whereby the ferrous chloride is changed into an oxychloride of iron. "This reacts on the hydrogen in bubbles adhering to the cathode, and thereby eliminates the cause of the bad quality of the deposits." The electrodes, therefore, are rotated. Besides the oxychloride, ferric chloride is also produced. To prevent the ferric chloride to be converted back into ferrous-salts the electrolyte is passed in a separate cell over iron shavings. The solution should become chestnut brown and not foaming. The higher the current density employed the greater must be the speed of the rotating cathode and the higher must be the temperature. At 1000 amperes per square meter the suitable temperature is 75 to 77 deg. C. The concentration of the liquid must be constant and be chosen according to its depolarizing power; it is maintained by adding fresh liquid to it. The greater the speed of circulation of the electrolyte, the lower will be the proportion of phosphorus. Air can be injected in varying quantities, forming basic salts for the depolarization. (1,086,132, February 3, 1914.)

**Manufacture of Iron.**—**Augustin E. Bourcoud**, of London, England, wants to reduce iron from its ore by means of gases. The $CO_2$ resulting is regenerated again. Comminuted or granulated ore and flux travel under agitation through a stream of CO and some $CO_2$, and the reduced metal is then melted in an electric furnace. Injurious moisture, organic and volatile impurities are eliminated by hot air, hydrogen is eliminated by coke in a regenerator, sulphuric gases by lime above 900 deg. C. Sulphur in metal is removed in the electric melting furnace. The furnace is arranged to utilize all waste heat; it controls temperature and composition of gases, waste products and charge. In Fig. 1 producer gas from *o* is burned in the stove inlets *n*. the gases leaving through chimney *d*. Air is highly heated in stove *a* and distributed to supply the producers *o*, to burn gas for heating stoves, while a third part passes through the inclined rotary heater *g* to the chimney *d*. The charge enters *g* in opposite direction, where it is dried. The hot producer gases then reduce it in the reduction furnace *h*. The gases, now rich in $CO_2$ are highly heated in stove *b* and regenerated with coke in *i*, heated again in *c*, desulphurized in *s* and used over again in furnace *h*. The reduced iron is then discharged into either electric furnace *k* or *k'* by slide valves. (1,086,133 and 1,086,134, February 3, 1914.)

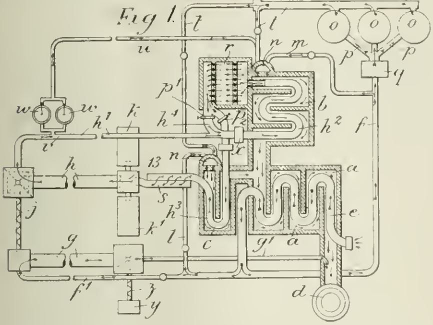


FIG. 1—IRON REDUCTION BY MEANS OF GASES

**Refining Steel.**—Low-carbon steel can be made or dephosphorized in an electric or open-hearth furnace by an oxidizing slag when adding manganese from time to time into the bath, according to a patent of **Axel Hethey**, of London, England. The charge should contain from 0.25 to 1.00 per cent Mn., which prevents a solution of iron oxide in the metal, yet oxidizes the phosphorus and removes also oxygen and sulphur. According to another feature of this process, the oxidizing slag may be left in the furnace and to prevent oxide being dissolved, the slag is stiffened with lime or dolomite, so that the heat can be finished with increased temperature to render pouring easier. (1,089,410, March 10, 1914.)

**Furnace Roof.**—A water-cooled flat roof, especially adapted for open-hearth furnaces was invented and patented by **Edwin E. Slick**, of Pittsburgh, Pa. Ordinary buckstaves support a series of water-cooled boxes, forming supports or girders. The bottom of said boxes has a dove-tail groove, co-acting with firebricks of similar shaped projections. The upper diagram of Fig. 2 shows how the remaining space 9 is filled with small bricks or mortar, allowing the firebricks being replaced independently. The lower diagram is a modified form, in which the recesses allow suspension by means of washers and bolts from the water-cooled boxes. (1,088,634, February 24, 1914.)

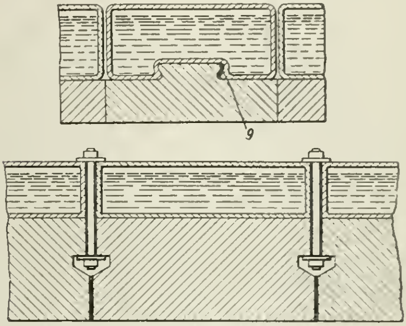


FIG. 2—FURNACE ROOF

**Reduction Without Smelting.**—Among the proposals to reduce iron and other oxide ores without resorting to smelting, is that of Mr. **Harvey C. Alford**, of St. Louis, Mo. His patented process consists in heating externally a charge of ore in a finely divided state, to a temperature below the point of fusion, mixing the heated ore with powdered coal, without access of air, and then agitating and heating this mixture in a suitable container to a temperature approximating 1000° F. The operations are carried out in revolving drums, the discharge of the first mixing with coal and entering the second. An excess of carbonaceous fuel is maintained to avoid the occurrence of reversible reactions between the reduced metal and any source of oxygen such as carbon dioxide. The product is reduced metal or sponge, mixed with the excess of fuel which may be removed from the metal in any suitable manner. (1,097,156, May 19, 1914.)

**Manufacture of Steel.**—According to a process of refining steel, whereby phosphorus, oxides, silicates and other impurities are removed, patented by Mr. **Albert Patton**, of McKeesport, Pa., metal that has been blown in the Bessemer converter, in which carbon, silicon and manganese have been reduced as low as possible, is treated as follows: Pour into an acid-lined intermediate receptacle, and from this into a basic-lined receptacle, care being taken to prevent the acid slag from entering the basic-lined receptacle. Materials for forming a basic slag are added to the latter before or during the pour. Phosphorus, being present in the Bessemer metal as $P_2O_5$, is absorbed by the basic slag. Manganese or re-carburizer can be added, if desired, in the basic-lined receptacle. (1,091,588, March 31, 1914.)

**Bessemer Converter.**—According to an invention of Mr. **Joseph V. Bretaud**, of Highland Park, Mich., the cost of construction and operation of a converter plant may be reduced by using converter shells comprising an upper and a lower section. Each section is removable from its support independently of the other, so that when the lining gives way in one part, it is necessary only to remove that section in which the break occurs. The removed section, having its lining exposed, cools rapidly and can be repaired quickly. The inventor claims that with this construction, two converters can produce the same number of heats otherwise obtained from three ordinary converters. (1,088,401, Feb. 24, 1914.)

### Gold and Silver

**Apparatus and Method for Filtering Slimes.**—A number of patents recently granted to Dr. Charles Butters, of Oakland, Cal., disclose his latest ideas in slime filtration, and particularly his methods of avoiding conflict with the ideas of other inventors regarding dislodgment of the filter cake from the fabric. Heretofore it has been the practice to effect dislodgment by air pressure applied internally to the leaf, and it has been assumed that such pressure was necessary to secure dislodgment in economical time. This application of compressed air has resulted in certain requirements in the construction of filter leaves, notably the use of outside strips fastened at intervals to the filtering medium, or stitching the two sides of the leaf together, for the purpose of preventing ballooning when internal pressure was applied. This manner of construction has resulted in reducing the available filtering area of the leaf, as well as weakening it and shortening its life.

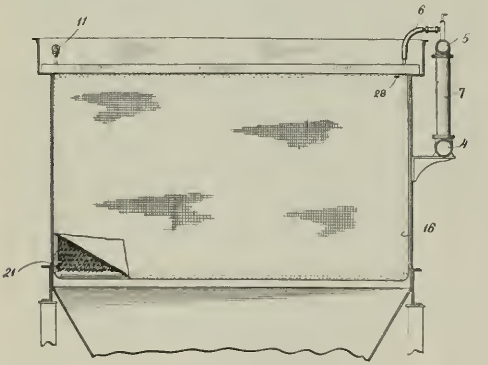


FIG. 3—NEW VACUUM FILTER LEAF

Mr. Butters has discovered that internal pressure is not necessary to the dislodgment of the cake, and that this operation can be accomplished by saturating the entire area of the filter medium with water, thereby destroying the adhesion of the cake. Water is applied internally, but not under pressure, and a relief valve is provided to permit the complete expulsion of air as the leaf fills with water. "It is understood that the cake may be, and preferably is, dislodged while the leaf is submerged in wash water. This means that there will be considerable hydrostatic pressure on the outside of the leaf. It has been found by experiment that the difference in specific gravity of the more or less dirty tank wash water and the relatively clean cake-dislodging water would be sufficient to maintain a column of the relatively clean water inside the leaf several inches higher than the level of the tank wash water, so that the relief valve (for expulsion of air) and the inlet for the cake-dislodging water may be several inches above the surface of the tank wash water without producing greater pressure inside the leaf than the outside pressure on the leaf."

By this means the external hydrostatic pressure may be balanced but can never be exceeded by the internal hydrostatic pressure, and yet the fabric may be moistened by water applied internally, and the cake easily dislodged. This system of treatment also makes it possible to use a lighter filter fabric and to dispense with bracing, stitching, etc., formerly used to prevent ballooning.

The construction of the filter leaf is shown in the drawing Fig. 2, in which a frame of pipe or tubing is covered with a bag of duck or other fabric. Inside the bag is a filler of cocoa matting to keep the sides of the bag apart when vacuum is applied. The lower horizontal member of the frame is perforated or slotted along its upper side, and is connected to a vacuum pump by means of the pipe 16 and flexible connection 6. The upper horizontal member also is perforated or slotted along its lower side, and connected with the air-relief valve 11. Plugs are placed in the frame at 21 and 28. The air-relief valve is of any kind that will prevent the ingress of air when the leaf is under vacuum, but will allow air to escape when the leaf is filled with water.

In operation, a cake is formed on the leaf, and washed in the usual manner. When it is ready to be dislodged, water is admitted to the leaf by way of pipes 4, 7, 5 and 6, filling the leaf from the perforations or slot in the lower horizontal frame-member. As the water rises in the leaf the air is expelled through the relief valve so that the water finally fills the leaf completely and saturates the fabric. The cake is automatically and rapidly dislodged. (1,100,217-18-19-20-21-22-23-67, June 16, 1914.)

**Cleaning Filter Leaves with Lactic Acid.**—The use of a solution of lactic acid to remove deposits of lime from filter leaves has been patented by Mr. **Paul F. Leach**, of Wollaston, Mass. The patent is assigned to Moore Filter Co., of New York City. The inventor states that a solution of lactic acid in the proportion of 1 lb. of the commercial product, which is of 22 per cent strength, to 25 lb. of water, gives satisfactory results. Heating the solution to about 150 deg. F. accelerates the dissolution of the lime. Cold solutions will cleanse the leaves in about an hour and hot solutions in half that time. The fabric is not injured in any way; its fibres remain soft and flexible, and are not shrunk by the action of the lactic acid. (1,101,639, June 30, 1914.)

**Apparatus for Precipitating Metals from Solution.**—According to the specifications of a patent granted to Mr. **Frank A. Ross**, of Spokane, Wash., and assigned to Chalmers & Williams, of Chicago Heights, Ill., the inventor proposes to precipitate, say gold-bearing cyanide solution by causing it to flow successively through a number of revolving cylinders containing solid precipitant in the form of aluminium. The cylinders are perforated, and mounted on hollow, perforated shafts in wooden tanks. The solution flowing into the first tank of the series fills the cylinder where it is acted on by the precipitant. It flows out by way of the perforated hollow shaft and thence into the next box where the operation is repeated. Electrodes may be placed in each compartment, the idea being that electrolytic action will aid in precipitation. (1,101,569, June 30, 1914.)

### Zinc

**Controlling the Formation of Zinc Dust in Smelting.**—Preheating the smelting charge before placing it in the retort, is the method proposed and patented by **Alex Roitzheim**, of Düren, Germany, for preventing or minimizing the production of zinc dust in the smelting of zinc ores. He states that zinc dust is formed mainly in the first three to six hours after charging the retorts, and mainly before the beginning of the reduction of the charge. This he ascribes to the fact that when the mixture is placed in the retorts in a cold condition, the reduction commences at the outer portions where the charge is in contact with the hot walls of the retorts. The zinc vapor there produced passes through the cold interior of the charge on its way to the condenser, and becomes suspended as zinc dust, entering the condenser as such. When the entire charge becomes heated, the zinc fume begins to condense as liquid. He therefore proposes to preheat the charge to a temperature of 600 deg. C., which is between the temperature at which reduction commences and condensation occurs. (1,100,490, June 16, 1914.)

**Electric Zinc Smelting.**—According to the specifications of a patent granted to Mr. **Heinrich Specketer**, of Griesheim-on-the-Main, Germany, one of the sources of difficulty in the electric smelting of zinc where the charge is used as a resistor, lies in the fact that the bottom of the charge becomes a better conductor than the overlying layers, due to the greater density of the former portion. This results in an uneven reduction of the mass. In order to obviate this difficulty Mr. Specketer proposes to use a rotable electric furnace in which the position of the charge can be shifted from time to time, thereby maintaining more even conditions of resistance and smelting. Electrodes are placed at each end of the furnace, one near the exit for fumes and gases and the other at the opposite end. Both electrodes extend over the whole inner end surfaces of the furnace and have their connections disposed 180° apart around the circumference of the furnace. (1,099,211, June 9, 1914.)

### Copper, Lead

**Separation of Copper from Nickel and Cobalt.**—Mixtures of minerals of copper, nickel and cobalt have presented difficulties in metallurgy that have not been wholly overcome. Mr. **Victor Hybinette**, of Fredericktown, Mo., recognizing the problem presented by this mineral combination, has invented and patented a process which he claims affords a successful method of treatment. "This ore consists of a mixture of chalcopyrite and linnæite or siegenite, with silica and dolomite as gangue. There are also present varying quantities of marcasite and galena. An average sample of this ore will analyze, chalcopyrite 10 to 20 per cent; linnæite 4 to 8 per cent; galena 1 to 6 per cent; marcasite 2 to 10 per cent; silica sandstone 50 to 70 per cent, and dolomite 10 to 30 per cent." If lead is present in sufficient quantity, the inventor prefers to remove it by ordinary wet concentration, after which he treats the residue according to the following method, which would be adopted if lead were not present in large quantities. The ore is ground to 10-mesh or finer, roasted to remove about one-half the sulphur which is present in the chalcopyrite and innæite and subject to magnetic treatment. Copper and cobalt minerals are removed; the tailing will contain some copper and nickel and all the lead, if the last was not removed as above stated. These can then be recovered by wet concentration. The magnetic concentrate, containing 12 to 20 per cent copper, 2 to 5 per cent cobalt and 2 to 5 per cent nickel, is then smelted to matte, roasted to remove all or practically the sulphur and leached with sulphuric acid. Copper will be dissolved and nickel and cobalt will remain in the residue. Little or no iron will be dissolved from this roasted matte. (1,098,443, June 2, 1914.)

**Filtration of Flue Dust from Furnace Gases.**—For the purpose of removing condensable metallic fumes and other solid matter from the furnace gases of lead and copper smelters, Mr. **Gilbert Rigg**, of Palmerton, Pa., proposes to use a device illustrated in Fig. 3. The patent is assigned to the New Jersey Zinc Co. The object of the apparatus is to provide a filter and condensing medium for the retention of solid matter carried in the furnace gas and to maintain the filtering medium in a condition for continuously performing its function. Referring to the drawing, A indicates a housing suitably supported and divided into compartments C, D and E by means of gratings consisting of a series of bars F of inverted V-shape and a series of flat bars G. Transverse rods I extend through the housing and are connected with rods K directly above the bars G. Mechanism for moving these rods I and connected rods K is shown at the left of the housing. The housing is further provided with hoppers P at the top and an outlet Q at the bottom. The gas to be filtered enters through the inlet R into compartments C, and the filtered gas takes its exit from compartment E through the outlet S.

The material resting on the gratings consists of coarse coal, coke, gravel, slag, stone, brick or the like. Accretions from the solid matter in the smelter fume build on the coarse material on the lower grating and form an efficient filter. When the accretions are so thick as to retard the draft, the mechanism is brought into operation, moving the rods K over the bars G, causing the accumulation to fall into the compartment below. At the same time an equal amount of fresh material is dropped from the upper grating. The operation of the mechanism may be arranged to be controlled automatically by a pressure regulator, or it may be left to the attendant who will regulate it according to the condition of the filter as indicated by the pressure. In some instances the reciprocation of the rods K may be made continuous. (1,095,676, May 5, 1914.)

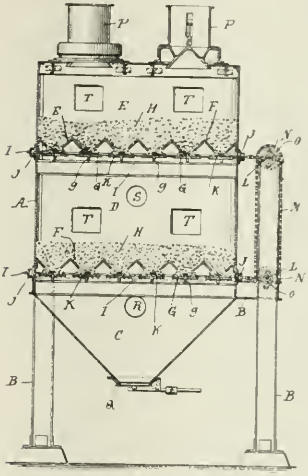


FIG. 4—FILTRATION OF BLAST FURNACE GASES

### Sintering Fine Ores

**Use of Addition Agent in Sintering.**—In the sintering process as devised by Mr. Ferdinand Heberlein, the mass of ore is exposed to the action of a current of air passed upwardly through the charge. A small percentage of the mass is not sintered, and in the case of agglomerating very fine dust it may happen that a considerable quantity may remain unsintered. To oversome this tendency Mr. **Edmond A. Preteeille**, of Nantes, France, proposes the addition of a salt, such as ferrous sulphate, to the charge, wetting the latter with a strong solution of the salt. It is his idea that the moisture thus added will be retained in the mass longer than if water only is added and that the salt will exercise a cementing effect on the fine particles, holding them together until they can be sintered by the heat of combustion. In the case of iron ore it would suffice to add sulphuric acid, which would form iron sulphate with part of the ore. In the case of iron sulphate solutions, 10 to 15° Be. has been found a suitable concentration. (1,096,054, May 12, 1914.)

**Improvement to Dwight-Lloyd Sintering Machine.**—Mr. Eugene H. Laws, superintendent of the Ohio & Colorado Smelting & Refining Co. at Salida, Col., has patented an improved construction of the sintering machine made by the Dwight & Lloyd Sintering Co., New York. In machines of this type a continuous traveling grate of pallets passes over a suction box for the purpose of inducing a down draft through the charge contained in the pallets. The edges of the pallets rest directly on the edges of the suction box and the transverse portions of the pallets drag over dead plates at the ends of the suction box, in order to prevent air entering the box otherwise than through the charge on the pallets. It so happens, however, that the wear on the edges of the pallets is much greater than on the transverse portions, with the result that eventually the transverse portions occasionally engage and tear the dead plates and strain the driving mechanism. Mr. Laws provides an adjustable support for the pallets as they pass over the suction box, whereby each pallet is carried in close proximity with the edge of the box, but out of wearing engagement with the edges or dead plates. (1,097,592, May 19, 1914.)

### Roasting Furnaces

**An invention relating to the air-cooling** of the central rotatable shaft of furnaces of the superimposed-hearth type, such as the Herreshoff, is patented by Mr. **Edward J. Fowler**, of San Francisco, Cal. The patent is assigned to the General Chemical Co., of New York City. Fig. 5 shows a cross-section of the shaft. It consists of a number of superposed sections fastened together by means of bolts. Concentric with the outer cylindrical wall, 3, is an inner cylindrical wall, 4, the two being held separate by radial ribs, 5. This structure forms an axial passage, 6, separated from and surrounded by an annular passage 7. Rabble arms used in connection with this shaft are hollow, and are divided into two interior passages by means of a longitudinal rib. When the arms are attached to the central shaft, one of the passages is in conjunction with the axial area, 6, and the other with the annular area, 7. Hence air passing up through the inner area of the central shaft is deflected through the opening 10, passes through the rabble arm and returns to the shaft by opening 9, and thence to the atmosphere. (1,100,426, June 16, 1914.)

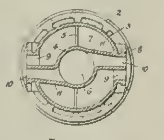


FIG. 5 — AIR-COOLED FURNACE SHAFT

**An air-cooled rabble arm** for use in roasting furnaces is patented by Mr. **Utley Wedge**, of Ardmore, Pa. It is shown partly in plan and horizontal section in Fig. 6. The rabbles or blades, 4, are cast integral with the arm. On the back of the arm and integral with it are helical ribs, 5. Both the blades and ribs are hollow and connected interiorly, so that there is a continuous passage from the blade at the outer end of the the arm to the one at the inner end. The rabble arm, 1, also is hollow, and communicates at its outer end with the hollow passage in the blades. By this construction it is possible for a current of air to flow from a passage in the central shaft to which the arm is attached, through the arm and back through the blades and thence to the air. (1,100,461, June 16, 1914.)

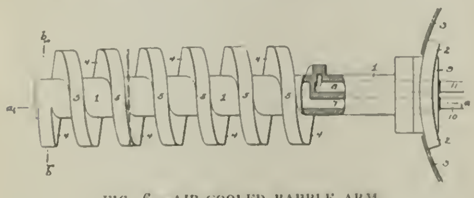


FIG. 6—AIR-COOLED RABBLE ARM

### Electric Furnace Construction

**Calcium Cyanamid.**—Mr. Walter S. Landis, of the American Cyanamid Co., of Niagara Falls, N. Y., produces calcium cyanamid in apparatus shown in vertical and horizontal cross-section in Fig. 7. 1 is a furnace lined with refractory material and provided with a lid 7. Inside the furnace there is a foraminous vessel 2 with holes of ¾ or 1 inch diameter covered inside with a textile fabric to prevent the carbide from falling out. The nitrogen gas is admitted through 11 into the annular space between the outer furnace wall and the inner vessel and enters into the inner vessel through the open top and through the holes in the sides and bottom. In construction c there is also a central hole provided for the passage of the nitrogen gas. 3 and 4 are a number of carbon resistors heated electrically to produce the desired reaction. Their connections 12 to the leads 5 and 6 are made of large diameter to heat them to a lower temperature and prevent their destruction by impurities in the nitrogen gas. 15 and 16 indicate the proceeding zones of reaction. With this construction the life of the resistors is very much prolonged. Further, with several resistors the reaction is much quicker than with a single one. (1,103,060, 1,103,061, 1,103,062, July 14, 1914.)

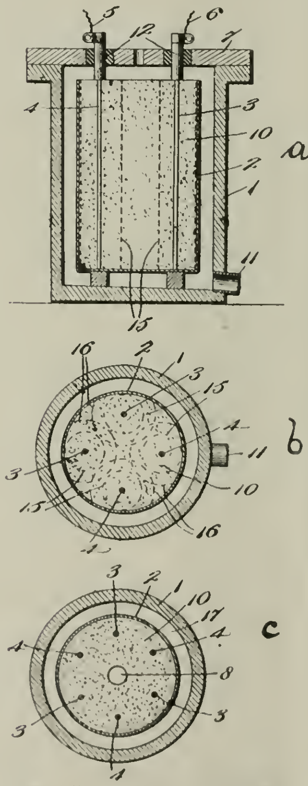


FIG. 7—CALCIUM CYANAMIDE FURNACE

**Electric Furnace.**—The Rennerfelt furnace was described in some detail in our April issue, page 275. A patent has now been granted to Mr. **Ivar Rennerfelt** for the principal feature of the furnace, namely, the arrangement of the electrodes. The second claim refers to "the method of generating heat by means of electric arcs consisting in passing two-phase currents along and between two opposing electrodes to the end of a third electrode at right angle to and symmetrically located between the first-named electrodes so as to cause an electric arc to burn between the ends of all the electrodes, strongly deviating away from the ends of the electrodes in the direction indicated by the symmetrically located electrode." (1,103,379, July 14, 1914.)

**Abrasive Compounds.**—A patent has been granted to **Thomas B. Allen**, of the Carborundum Company of Niagara Falls, N. Y., for the production of artificial garnet, an abrasive, by melting gradually 2240 lb. of calcined magnesia, 1493 lb. of alumina and 2760 lb. of silica. The molten mass is cooled slowly by insulation with some charge and when solid is removed at a temperature of 1200 to 1500 deg. C. and crushed while cooling with water to prevent dissociation. Similar compounds can be produced of the form $3R'OR''_2O_3 3SiO_2$, where R′ is calcium, magnesium or ferrous iron and R″ is aluminium, ferric iron or chromium. (1,087,705, February 17, 1914.)

**Electric Furnace.**—**Bayard Guthrie** and **Joseph P. Karch**, of Pittsburgh, Pa., have invented a combined electric arc and resistance furnace. The crucible 5 is supported and insulated by fire brick from the bottom plate. The surrounding bricks have a pair of chambers 11, separated by a refractory partition 12-12 to prevent arcing between the electrodes and to hold the crucible when tilting. The electrodes 13-13 fit snugly to the crucible bottom and flare at the top, the space between is filled with broken carbon 14 to break up the electric arcs between electrodes and crucible. The electrode lugs 13′ connect with copper electrodes and cables and an arrangement to adjust and hold the crucible by means of the electrodes. The heat is concentrated at the crucible top. This furnace is particularly adapted for direct or single-phase alternating current. The spout is so arranged as to discharge the metal direct into the center of a swinging mould, and touching its side walls. (1,086,164, February 3, 1914.)

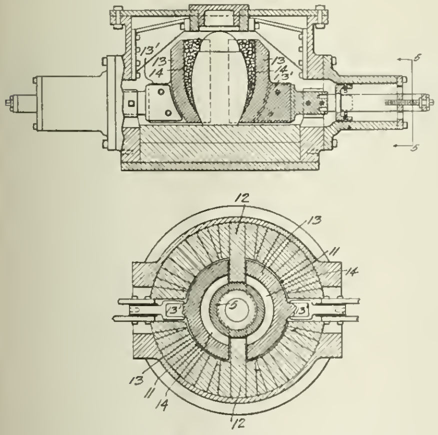


FIG. 8—ELECTRIC MELTING FURNACE

**Electrodes.**—The fact that the energy losses through heat conduction in the electrodes of electric furnaces exceed those caused by electric resistance is made the object of a patent granted to Dr. J. W. Richards, Bethlehem, Pa. The electrodes are built with gaps extending inward in different shapes. These gaps are either left as open spaces or are filled with material of low heat conductivity and thus lengthen the path of heat currents to the outside of the electrode. For example, it is possible to effect a large saving in electric energy by reducing the heat conductance 25 per cent., even though the electric conductance is thereby diminished 50 per cent. (1,088,296, February 24, 1914.)

**Protective Coating for Electrodes.**—The production of a coating of titanium nitride on furnace electrodes and other refractory materials is patented by Mr. **Samuel H. Fleming**, of Cleveland, O., and assigned to the National Carbon Co. of the same place. Titanium nitride is stable at high temperatures, is non-porous, tough and hard, and otherwise possesses qualities that make it valuable as a protective coating for substances that are subjected to very high temperatures in an electric or other furnace. In order to form the coating a mixture of rutile and some binder is pressed on the article to be coated, which is then baked at a high temperature in the presence of nitrogen. Owing to great affinity of titanium for nitrogen, the former is converted into nitride. A first coating of titanium carbide may be desired, as this substance wets carbon and enters the pores of its exterior surface and forms a perfect union with the carbon. This may be formed by applying a mix of titanium and carbon and heating with exclusion of air, forming titanium carbide. After the coating of carbide is formed the article may be heated in an atmosphere of nitrogen, thus converting part of the carbide into nitride. This latter conversion may be stopped before all of the carbide has been changed, if an inner coating of carbide is desired. (1,098,794, June 2, 1914.)

**Aluminium Nitride Lining for Furnaces.**—In order to overcome the great difficulties encountered in forming suitable linings for furnaces in which temperatures of, say 2000° C. are employed, Mr. **Ottokar Serpek**, of Paris, France, proposes the use of aluminium nitride. It possesses the property of being easily agglomerated and can be molded into various forms by using a binder such as sodium silicate. Such material resists the corrosive action of many chemical substances and may be advantageously used in industrial furnaces of different kinds. (1,099,131, June 2, 1914.)

### Phosphoric Acid

**A method of producing phosphoric acid from phosphate rock has been patented by Mr. Frank S. Washburn**, president of the American Cyanamid Co., Nashville, Tenn. The process disclosed is an excellent illustration of the possibility of bringing about chemical reactions at temperatures obtainable only in the electric furnace, and of the economic value of a combination of fuel and electric furnaces in commercial operation.

The chemical basis of the operation is the displacement of phosphoric acid from its compounds by means of silica. It is found, however, that the replacement is far from complete at temperatures obtainable in fuel furnaces, say 1400 deg. C. On the other hand, if an electric furnace be used, it is possible at higher temperatures to greatly increase the yield of phosphoric acid, and if coke be added to the smelting charge, the evolution of phosphorus can be made almost quantitative. Nevertheless, the cost of electric energy is too great to permit of carrying out the process economically. Thus, phosphate rock contains from 10 per cent to 20 per cent of calcium carbonate. The carbon dioxide can be driven off from this compound by the heat evolved in burning from 0.012 to 0.025 ton of coal per ton of rock, whereas it would require from 200 to 300 hp-hr. of electrical energy for the same purpose. With coal $3 per ton and electricity at $15 per hp. year, the comparison of cost is as 7½ and 15 cents, respectively, are to 40 and 80 cents.

respectively. The heat in the slag, per ton of rock charged, is equivalent to 1600 hp-hr., or $3.20 worth of electrical energy; while coke required for heating the charge is worth only $2. Thus a combined process may be more economical than the electrical alone. Phosphate rock mixed with silica and a suitable fuel can be smelted in a small blast furnace, producing a slag which can then be further heated in an electric furnace, with coke added to complete the reduction of phosphorus. Mr. Washburn has further demonstrated that by the use of very rich oxygenated air, which is conveniently obtained as a by-product from a liquid air plant, he can get very fusible slags that can be tapped from the blast furnace without difficulty.

The gases evolved from both shaft and electric furnaces are led to a common oxidization chamber, and any unoxidized phosphorus is there condensed by absorption in water or ammonia. By the use of a combination of fuel and electric furnaces, it is possible to obtain an almost complete extraction of phosphorus from the rock, with an expenditure of electrical energy less than half that required by an electric furnace alone. Slags of 45 per cent silica offer no trouble in the shaft furnace when enriched air is used. (1,100,639, June 16, 1914.)

### Electrolytic Processes

**Sodium Hydroxide and Hydrochloric Acid from Brine by Electrolysis.**—In a patent of the late **Eugene A. Byrnes** a diaphragm cell is proposed, divided up into a series of compartments containing alternately brine solution and water. In Fig. 9 the compartments 1, 3, 5 contain NaCl solution, the compartments 2 and 4 contain $H_2O$; 1 contains the anode and 5 the cathode. The partitions between the successive compartments are used as bipolar electrodes. They may consist, for instance, of wire gauze, covered by porous diaphragms. At the partition between 1 and 2 the Na cations from 1 and the OH anions from 2 come together and form Na OH which is drawn off. At the partition between 2 and 3 the H cations from 2 and the Cl anions from 3 come together and form HCl which is drawn off. The bipolar electrodes need not be inert as the electrode between 1 and 2 may consist of oxidized copper and the electrode between 2 and 3 of lead; in that case the copper electrode is oxidized by the hydroxyl and again reduced by the sodium ion with the production of sodium hydroxide, while the lead electrode is chloridized and again reduced by hydrogen with the production of hydrochloric acid; these products are washed out of the cell by water. The inventor proposes to short-circuit the electrodes at each side of the compartments 2 and 4 as indicated by the dotted lines 12. "The current then shunts around the bodies of water or other electrolyte in these intermediate compartments. The sodium and chlorine set free in the electrodes, however, with the intermediate body of water, constitute a voltaic cell, the hydroxyl of the water oxidizing the sodium while its hydrogen combines with the chlorine." (1,102,209, June 30, 1914.)

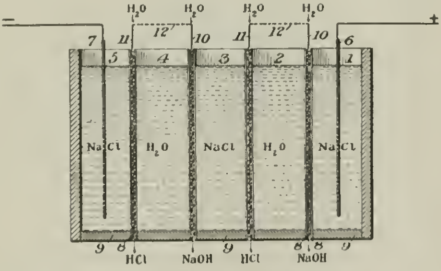


FIG. 9—SODIUM HYDROXIDE AND HYDROCHLORIC ACID FROM BRINE

## London Notes

### The Iron and Steel Institute

The autumn meeting of this Institute will be held in September in Paris in the Hall of the Comitè des Forges. Visits to the Basilica of St. Denis and to the works of the Compagnie des Metaux, as well as to Nancy for the purpose of inspecting the metallurgical works and mines, have been arranged.

### The Institute of Metals

The autumn meeting will be held on September 10 and 11 at Portsmouth. Arrangements have been made for inspections of the docks and of the works of Messrs. Samuel White & Co., at Cowes.

### The Congress of Mining, Metallurgy, Engineering and Economical Geology

The sixth meeting of this congress will be held in London next year and will extend from July 12 to 17. Each of the four sections will conduct independent proceedings.

### Market Prices—June, 1914

| | £ s. d. |
|---|---|
| Aluminum ingots, ton lots | 85. 0. 0 |
| Alum lump, loose, per ton | £5.5.0 to 5.10. 0 |
| Antimony, Star Regulus, ton | £26.15.0 and 27. 5. 0 |
| Borax, British refined crystal, cwt | 17/6 to 18. 6 |
| Copper sulphate, ton | 21. 0. 0 |
| Caustic soda, 70%, ton | 10. 0. 0 |
| Copper ore, 10% to 25% unit | 10/3 to 10. 9 |
| Ebonite, red., lb | 1. 6 |
| Hydrochloric acid, cwt | 5. 0 |
| India rubber, Para, fine, lb | 2. 9½ |
| Mica in original cases, medium | 3 6 to 6. 0 |
| Petroleum, Russian spot, gal | 9¼ |
| Quicksilver (Spanish), bottle | 7. 0. 0 |
| Sal Ammoniac, cwt | 2. 2. 0 |
| Sulphate of ammonia, ton | 10.15. 0 |
| Sulphur, recovered, ton | 5.10. 0 |
| Shellac, cwt. | 3. 4. 6 |
| Platinum, oz., nominal | 9. 5. 0 |
| Tin ore, 70%, ton | £82.0.0 to 84. 0. 0 |
| Zinc, Vieille Montagne | 25. 2. 6 |

Copper opened at £63 and declined till the 8th, £61.10.0, then recovered to £62 (11th), and again fell away to £61.5.0 (17th), and after a slight recovery (18th) to £60.1.3 (26th), showing slightly better on the next few days and closing £61.

Tin opened at £142 and was uneven over the first fortnight between the limits of £137 and £140. On the 16th it went lower, £137,15.0, but hardened slightly on the 23d to £139.7.6. A larger drop brought it on the 25th to £135.5.0, but closes slightly stronger £140.5.0.

Haematite opened at 61s. and has remained quite steady at this price.

Scotch pig opened 57s. 3d. and has been rather weak, showing 57s. 3d. on the 4th and 57s. 1½d. on the 16th, to which prices after recovery to 57s. 6d. on the 9th it again dropped on the 26th, declining to 57s. on the 29th.

Cleveland opened at 51s. 6d. and declined slowly to 51s. 1½d. on the 17th, and again, after slight recovery on the 25th, continuing downward to 51s. on the 29th and closing same price.

Lead opened £19.10.0 and reached £19.17.6 on the 4th, afterward rather lower, but again stronger on the 15th and rose to £20 by the 19th, after which it declined, reaching £19.5.0 by the 29th, but better at the close £19.10.0.

# Synopsis of Recent Chemical and Metallurgical Literature

## Iron and Steel.

**Tilting Open-Hearth Furnaces.**—A very interesting series of experiments has been carried out at Witkowitz, Austria, to compare the efficiency of the Talbot furnace with the Wellman tilting furnace and the stationary 69-ton basic open hearth. Dr. Schuster, the general manager of the Witkowitz Iron and Steel Works, gave a detailed account before the semi-annual meeting of the German "Verein deutscher Eisenhüttenleute" of the requirements of these works and of the considerations and deliberations preceding the final decision to build a new open-hearth plant. This plant was to be big enough to take care of their rolling mills and forging presses, capable of extension and yet flexible enough to allow a change of processes in case one or the other of the new furnaces should be no success.

So far England and America had been the pioneers of the tilting open-hearth furnace for continuous operation, whereas continental Europe, aside from a few unfortunate trials, showed no inclination for the Talbot process. As a matter of fact, the pig-iron-ore process promised to be the most economical under the local conditions and circumstances. And although two German experts who had investigated every English Talbot furnace by order of the company came to the conclusion that, only under certain restrictions, it would be advisable to use this process, Dr. Schuster decided to build two Talbot furnaces of 300 tons capacity each, three stationary 60-ton basic furnaces and one 60-ton Wellman furnace, the latter one in order to compare stationary and tilting furnaces of equal capacity. One of the Talbot furnaces was to serve a heatable mixer as the blast furnaces are at a distance of 1.3 miles from the steel plant, and the other should perform the same work in case the experiments should fail. This, however, did not happen, the new installations proved to be most successful and the extension of the plant is planned with Talbot furnaces. It also contains two electric furnaces, one of 2-ton capacity for melting ferromanganese, the other a 6-ton furnace for special brands of steel.

When working with 5 per cent of scrap in the Talbot, 13 per cent in the Wellman, and 25 per cent in the ordinary open hearth, the first cost of the three furnaces compares 1659:1259:1000. Figured per ton of product, however, this proportion is reversed and reads: 882:1070:1000, which shows the superiority of the Talbot furnace as to cost of erection. With pig iron containing 1.1 per cent of phosphorus, 1 ton of steel is produced in the three types in the same order of rotation in 4 min. 30 sec., in 7 min. 12 sec., and in 8 min. 30 sec. The metallic iron reduced from the additions of ore is 86 per cent, 80 per cent and 78 per cent respectively, and every quality of steel required is produced as reliably as in the stationary furnace.

Those present at the meeting were provided with extensive maps, tables and cost sheets showing the advantages of the combination as worked out for the special requirements at Witkowitz. They are too widely different from American conditions to be treated in detail here. Those familiar with the art will be interested to know that contrary to the prevailing tendency in building the furnaces a very limited use of water-cooling devices has been made and air cooling applied wherever possible.

During the discussion of the paper it developed that the Königshütte in Upper Silesia, for a few months, has had tilting open-hearth furnaces, a similar process being in operation of which little was known; the results obtained were so far very similar to those cited above. When speaking at the subsequent banquet, Dr. Schuster remarked that he had been more liberal than customary among the members of this society, in communicating his experiences for the common benefit of all, and hoped that his example would be followed by many successors.

## Gold and Silver

**Resistivity of Pure Silver, Solid and Molten.**—In a paper published in the *Journal* of the Franklin Institute, July, 1914, Dr. Edwin F. Northrup announces the results obtained in determining the resistivity of pure silver at temperatures between 20 deg. C. and 1340 deg. C. The silver used was very pure, being part of the supply used by Prof. G. A. Hulett in his study of the silver voltameter. For determining the resistivity between 20 deg. C. and 60 deg. C., the author used soft drawn wire, and oil-bath, mercury thermometer and Kelvin double bridge. The same silver was then used in a container of magnesite 40 parts and alundum 60 parts. The results were not checked, partly for lack of time and partly for the reason that the author's previous experience with the method makes it seem improbable to him that any serious errors have crept in. The table below gives the results of the determination. At the moment of fusion the resitivity suddenly increases from 5.5 to 16.6 microhms. The measurement was not carried to higher temperatures on account of failure of the thermocouple, due to opening of its circuit.

| Degrees Centigrade | Microhms per Centimetre | Ratios, $\rho t/\rho t_1$ | Remarks |
|---|---|---|---|
| 20 | $1.65_9$ | | |
| 60 | $1.90_6$ | | Increase per 100° C = 0.60 microhms |
| 960.5 | 8.4 | | Silver solid. |
| 960.5 | 16.6 | $\rho m/\rho s = 1.98$ | Silver molten. |
| 1000 | 17.01 | | Temperature coefficient calculated from 1000° C = .00069 |
| 1100 | 18.19 | | |
| 1200 | 19.36 | | |
| 1300 | 20.54 | | Increase per 100° C = 1.177 microhms |
| 1340 | 21.01 | | |

## Copper

**Proposed New Converter and Converter-Smelting of Ores.**—In the June, 1914, *Bulletin* of the American Institute of Mining Engineers, Mr. Herbert Haas publishes a long article describing the construction and proposed operation of a new type of copper converter, in which it is proposed to extend the matte-bessemerizing process to the direct reduction of fine pyritic ore. Converter-smelting is not new, having been practised to some extent at Great Falls and Cananea; but Mr. Haas makes some novel proposals which are intended to widen the scope of the process. His paper is too long to present in more than a very brief abstract.

The general premises on which the author makes his proposal are as follows: The cost of copper converting is now about $5 per ton of copper, or $2 per ton of 40 per cent matte. If further economy is to be attained a process must be adopted which will be cheaper than the present established practice of combined blast-furnace smelting and bessemerizing operations. The author explains that his proposed process will not displace existing methods, for converter-smelting is limited to the treatment of ore containing sufficient iron and sulphur to furnish the heat required to produce and sustain the smelting and bessemerizing temperature. The tonnage of concentrate that can thus be smelted depends chiefly on their iron and sulphur contents; a decrease in these two constituents in the concentrate requires an increase of them in the matte of the charge. Thus the matte should be low in copper and high in iron and sulphur, in order to furnish the requisite heat to smelt the more silicious concentrate, which would be high in copper but low in iron. The copper concentrate would then take the place of silicious flux to slag the iron in the matte.

As the rate of smelting and the elimination of iron and sulphur depend on the rate at which air is blown into the charge, Mr. Haas has given attention to the design of a converter-smelter that would provide larger volumes of air than are now required. Further, in order to gain technical efficiency the operation must be carried out in such a way as to allow no free oxygen to be discharged in the waste gases. Finally, the air should be used at as low a pressure as possible to reduce the cost of compressing.

Mr. Haas discusses the development of copper converting, and then describes his proposed converter. Briefly, it is a vertical type, bottom-blow converter with elevated tuyere bottom. The shell is lined with magnesite bricks. The most radical departure is the proposed use of a large number of tuyeres of small cross-section, confined to a central area in the converter bottom. Tabulated data are given showing an example of blowing a charge in such a converter. The smelting of fine pyritic ore or concentrate would be accomplished by blowing it into the charge with the compressed air.

The author discusses the air requirements for converting; the cost of power to furnish air, and the thermo-chemistry of the converting process.

### Magnetic Separation of Minerals

**The Ullrich Magnetic Separator.**—An article by Mr. W. Mewes in the *Mining & Engineering Review* (Australia) for May and June, 1914, describes the construction and method of operation of the Ullrich magnetic separator for both wet and dry work, and gives the results of tests. The Ullrich machine has stationary poles disposed about an annual support, and an annular armature rotating above them. Magnetic fields are generated in the intervening space. The armature is divided into a number of concentric rings of V-section, creating in each magnetic field as many zones of action as there are rings to the armature. Ore may be fed either wet or dry, but different constructions are used to meet the two different conditions. The following table gives some practical results obtained with the machines.

| Ores | Content, per Cent | Non-magnetic Product, per Cent | Magnetic Product, per Cent | Recovery, per Cent |
|---|---|---|---|---|
| Tin-tungsten | 30 $WO_3$ | 3 $WO_3$ | 68 $WO_3$ | 90 $WO_3$ |
| | 32 Sn | 62 Sn | 4 Sn | 95 Sn |
| Tungsten conc | 62 $WO_3$ | 10 $WO_3$ | 72 $WO_3$ | 97 $WO_3$ |
| | 3 Bi | 12 Bi | 0.15 Bi | 95 Bi |
| Tin, ilmenite | 10.61 Sn | 66.83 Sn | 0.03 Sn | 99.5 Sn |
| Spathic zinc | 15.9 Fe | | 30.1 Fe | |
| | 3.8 Mn | | 8.2 Mn | 75.2 Mn |
| | 27.8 Zn | 49 Zn | 2.5 Zn | 92.0 Zn |
| Spathic copper | 38.9 Fe | | 39.8 Fe | 68 Fe |
| | 1.04 Cu | 3.97 Cu | 0.13 Cu | 88 Cu |
| Hematite | 37.31 Fe | | 65.32 Fe | 80 Fe |
| | 0.238 P | | 0.025 P | |
| Roasted spathic iron | 37.2 Fe | | 48.1 Fe | 93.5 Fe |
| | 6.9 Mn | | 8.5 Mn | 89.5 Mn |
| Blast furnace dust | 43.0 Fe | | 57.3 Fe | 91.1 Fe |
| | 0.17 P | | 0.20 P | |

### Crushing and Grinding

**Grading Analyses by Elutriation.**—In reply to discussion on his paper on this subject before the Institution of Mining & Metallurgy, Mr. H. Stadler makes further remarks in *Bulletin* 117 regarding the usefulness of this method of making physical analyses of the finest portion of crushed ore. In view of the policy of fine grinding now in vogue in cyanidation, and of the losses attending the concentration of slime from base-metal ores, the author believes that elutriation should be more widely used for making grading analyses. The method of elutriation begins where screening stops, and besides being more accurate, it is in accord with practical operating conditions, as the handling of slime pulp consists almost exclusively of hydraulic methods.

"We are too easily inclined to consider slime as a definite product, yet the difference between one slime pulp and another may be just as great as between a 10 and 1000-mesh battery pulp. A percentage of moisture or a flow-velocity suitable for one slime pulp may be disastrous to another. The fact that the slimy portion of the ore is responsible for over 80 per cent of the total losses sufficiently warrants a closer investigation by the method of elutriation, which would certainly be a great help in tracing the causes of these losses, and a guidance for the introduction of possible improvements."

The proper operation of hydraulic classifiers can be accomplished only by correct dimensioning, and this, in turn, is involved with the velocity of the rising current of water which carries over the particles of desired size. From this empirically determined velocity and the flow quantities, expressed in fluid tons, the required classifying area may then be calculated by the following formula, in which 16.2 is the conversion factor from the metric to the British standards.

$$\text{Classifying area in sq. in.} \quad \frac{\text{Fluid ton per 24 hr.} \times 16.2}{\text{Velocity in mm. per sec.}}$$

The following example is given for calculating the diameter of a circular tube mill classifier, by which a 64-mesh battery pulp of 75 per cent moisture is to be classified into a thick underflow of 30 per cent moisture containing solids + 120 mesh, and on overflow containing the — 120 mesh portion:

**Intake**

| Mesh | Weight | Dry Solids |
|---|---|---|
| + 120 | 66 2/3 | 300 tons |
| — 120 | 33 1/3 | 150 " |

| | |
|---|---|
| 450 tons of solids, sp. gr. 2.7, | 166.6 fluid tons |
| water (75% of inlet pulp), | 1350.0 " " |
| | 1516.6 " " |

**Overflow**

| | |
|---|---|
| — 120 mesh, 100%, 300 tons, sp. gr. 2.7, | 55.5 fluid tons |
| water (89% of overflow pulp), | 1221.5 " " |
| | 1277.0 " " |

**Underflow**

| | |
|---|---|
| + 120 mesh, 100%, 300 tons, sp. gr. 2.7, | 111.1 fluid tons |
| water (30% of underflow pulp), | 128.5 " " |
| | " " |
| | 239.6 " " |

The velocity of water effecting a separation similar to that made by 120-mesh screen is 10.08 mm. per sec. Hence:

$$\text{Classifying area in sq. in.} = \frac{1277 \text{ fluid tons} \times 16.2}{10.08 \text{ mm. per sec.}} = 1060 \text{ sq. in.}$$

equivalent to the area of a circular classifier of, say, 3-ft. diameter.

The method of classifying by elutriation is based on different principles than sizing by screens. Neither is an accurate means of measurement, but each has its sphere of usefulness. While sizing by screens is suitable for the study of mechanical efficiency of grinding machines, grading elutriation is more trustworthy for the investigation of metallurgical problems, as it is in accord with condition of actual operation.

**Comparative Hardness of Ores in Tube Milling.**—In the April *Journal* of the Chamber of Mines of Western Australia, Mr. W. B. Blyth contributes "a simple and accurate method for comparing the hardness of ore sands judged from a tube milling standpoint." The comparison does not extend to any other crushing machine. Stadler's method for computing the grinding efficiency is used, but the regrind factor is only an arbitrary term used for want of a better. The method is as follows:

"A sample of ore to be tested (wet crushed) is graded (I.M.M. screens) until 8 lb. of a —20 + 40 sand is obtained. A charge consisting of 8 lb. of sand, 8 lb. of flintstones, 1-in. to 2-in. diameter, and 16 lb. of water, is introduced into a 5-gal. glazed earthenware ginger-beer barrel and ground for 90 minutes at 60 r.p.m. A sample of the ground product is then taken, dried and graded with a mechanical grader, 40, 60, 100 and 150-mesh I.M.M. screens. Grading occupies 20 minutes. The value of the grading in energy units is then calculated by Stadler's method and this amount, minus the original value in energy units, represents the regrinding factor in the table."

| Screen | Feed |  |  | Product |  |  |
|---|---|---|---|---|---|---|
|  | Mean Factor, Stadler | Per Cent | Energy Units | Per Cent | Mean factor, Stadler | Energy Units |
| + 40 | 17.5 | 100 | 1750 | 16.8 | 17.5 | 294.0 |
| + 60 |  |  |  | 29.2 | 20.0 | 584.0 |
| +100 |  |  |  | 16.4 | 22.0 | 360.8 |
| +150 |  |  |  | 6.6 | 24.0 | 158.4 |
| –150 |  |  |  | 31.0 | 26.5 | 821.5 |
|  |  |  | 1750 |  |  | 2218.7 |

Total energy units, product, 2218.7; feed, 1750; difference, regrinding factor, 468.7

**Cost of Power for Air in Converting.**—In discussing this subject (Bulletin, A. I. M. E., June, 1914) Mr. Herbert Haas makes the following observations: With a good boiler 1 lb. of coal will evaporate 8 lb. of water; a good steam turbine direct-connected with a turbo-blower will consume 12 lb. of steam per effective hp-hr.; so that 1.5 lb. of coal would produce an effective hp-hr. With fuel oil, an evaporation of 14 lb. of water can be obtained from 1 lb. of oil, so that not quite 0.9 lb. of oil would be required for one effective hp-hr. With Diesel engines a hp-hr. could be produced for less than 0.5 cent, with fuel oil costing $1.50 per bbl. of 330 lb., and including 12.5 per cent interest and amortization on the capital invested. One cent per hp-hr., however, is taken as the cost of power for purposes of calculation. For converting a 40 per cent ideal matte, the author gives 101.3 hp-hr. as the commercial requirement per ton of copper for furnishing air to the converter.

## A New Porous Mineral Filter Medium

In the numerous commercial processes employed by electrochemical, chemical and metallurgical engineers in their practice there is a wide-spread need for a suitable porous medium. For processes requiring a porous diaphragm or filtering medium such materials as canvas, asbestos fiber, loose mineral substances, etc., are resorted to. These at best offer many objections, among which are the necessary and expensive renewals due to the complete destruction or rapid deterioration of the materials used and clogging of the pores, also the interruption of the operation resulting from the frequent cleaning. In many commercial processes the question of filtering thoroughly, rapidly and cheaply is a most vital one and there has been and is a wide search for a material to accomplish this work satisfactorily.

A uniformly porous septum possessing resistance to high temperatures, acids and chemical solutions and as well as showing little liability to clogging of the pores by fine particles, approaches the ideal medium for commercial filtration of gases and liquids. The development of a new porous mineral medium termed "filtros" bids fair to overcome many filtering difficulties encountered in modern industrial fields.

Filtros is composed practically of silica and is consequently inert to all acids (with the exception, of course, of hydrofluoric), the weaker alkalies most commonly requiring to be filtered in commercial practice, and neutral chemical solutions of an organic or inorganic nature. It will also withstand temperatures up to 1800° F.

The method of producing these tile was discovered by Mr. J. E. Porter, of Syracuse, N. Y. Broad patent claims on the various features of the invention have been allowed. These have been acquired by the General Filtration Company, Inc., which company also possesses a number of other patents covering the use of porous mineral septa in many industrial arts. The Harbison-Walker Refractories Company by arrangement with the General Filtration Company, Inc., manufactures the tile for the General Filtration Company, Inc.

Filtros is a white, rigid and porous ware of excellent strength. It is made in the form of standard tile 12 in. x 12 in. x $1\frac{1}{2}$ in. and where this shape can be conveniently applied there are advantages in using this size. A great variety of shapes, however, are possible for devices of special design. The pores of the standard tile are so fine as to offer great resistance to the penetration of very small particles, yet the mass is so porous as to permit the free passage of the gases or liquids to be filtered; in some instances reducing the time of filtering 50 per cent and producing a filtrate of absolute clarity. Tile of other grades of porosity than that of the standard are also produced.

The true porosities of the finer grained tile are about equal to that of the standard but the pores are much more minute, and more numerous. These are capable of retaining finer slimes but do not allow as rapid a passage of fluid as do the coarser tile.

The tests in Table I show how the true porosities compare with the air ratings. The air rating is the number of cubic feet of air per square foot of area per minute that at the given pressure pass through the tile $1\frac{1}{2}$ in. thick.

TABLE I

| Grade | Cubic feet of air at 2-in. water pressure | Porosity per cent by void |
|---|---|---|
| 5-R | 12.0 | 40.10 |
| 7-R | 8.4 | 37.44 |
| 5-1 | 6.3 | 31.56 |
| 5-2 | 4.1 | 38.24 |
| 5-3 | 2.0 | 33.27 |
| 5-4 | .50 | 39.55 |

The resistant property of filtros to high temperatures and acid fumes indicates the probable field for it in bag house practice as well as for the filtration of combustible gases without the loss of sensible heat, which, in many cases, is most desirable.

In problems of cyanidation involving aëration the exceptional uniformity in the porosity of filtros indicates its utility in this connection. The air-rating tests of Table II bear emphasis on this remarkable uniformity of the tile. These, as above, show the amount of air per square foot of area per minute that at the given pressure passes through the standard tile 1½ in. thick.

Table II

| Specimen | Cubic feet per minute per square foot at given pressure in inches: 2 inches | 4 inches |
|---|---|---|
| 1 | 12.0 | 24.3 |
| 2 | 12.0 | 23.8 |
| 3 | 11.7 | 23.0 |
| 4 | 11.9 | 24.0 |
| 5 | 12.2 | 24.5 |

Further indication of the free flow of liquids through the tile is illustrated by the tests of Table III, which give the amount of water filtered per square foot of area of the standard tile 1½ in. in thickness at the given pressure.

Table III

| Head pressure | Gallons per minute per square foot area | Temperature of water |
|---|---|---|
| 5 ft. | 1.40 | 50° F. |
| 5 " | 1.39 | " |
| 10 " | 2.15 | " |
| 10 " | 2.15 | " |
| 15 " | 2.61 | " |
| 15 " | 2.60 | 57° F. |
| 20 " | 3.27 | " |
| 25 " | 3.42 | " |

Solubility tests in which filtros tile were immersed in chemical solutions for long periods at various temperatures show the inertness of the tile to acids, weaker alkalies and chemical solutions.

The tests in Table IV representing some commercial filtrations will be of interest.

Table IV.—Commercial Filtration.

| Solution | Strength per cent | Time immersed | Temp. deg. F. | Loss | Condition unchanged |
|---|---|---|---|---|---|
| Sulphuric acid | 96 | 24 hrs. | 200 | .02 | " |
| Sulphuric acid | 96 | 8 days | " | .023 | " |
| Hydrochloric acid | 2/3 of 37 | 24 hrs. | " | .017 | " |
| Nitric acid | 1 1/3 of 70 | | | | |
| Nitric acid | 35 | 8 days | " | .016 | " |
| Hydrochloric acid | 70 | 8 days | " | .026 | " |
| Water distilled | . | 35 days | " | .000 | " |
| Sulphuric acid | 20 | 35 days | " | 110 | " |
| Hydrochloric acid | 20 | 35 days | " | 140 | " |
| Nitric acid | 20 | 35 days | " | 080 | " |
| Zinc Sulphate | Saturated | 20 days | " | 040 | " |
| Mercury Bichloride | Saturated | 20 days | " | 021 | " |
| Potassium cyanide | 2.5 | 5 days | " | .042 | " |
| Potassium cyanide | .50 | 20 days | " | 09 | " |
| Potassium cyandie | .50 | 7 days | " | 013 | " |
| Calcium hydrate | Saturated | | | | |

Fltros has been proven by test to resist also the action of organic chemicals as well.

Applications for filtros will no doubt suggest themselves to engineers for a variety of uses, such as porous diaphragms in electrolytic processes and as a filtering medium for gases and liquids in the mining, metallurgical and chemical fields. As there is at present a wide demand for a reliable and strong filtering medium for just such purposes, it will be interesting to watch the career of filtros in commercial practice.

## Dry Kilns for Timber Products

While the subject of dry kilns for timber products is of special importance to furniture manufacturers and manufacturers of wood products in general, it should also be of interest to chemical engineers in view of analogy of the process with the drying operations in many chemical processes. For this reason attention may be called to the new catalog of the American Blower Company, of Detroit, Mich., on dry kilns for timber products. (Bulletin No. 20, Series 1. 64 pages, illustrated.)

The problem of lumber drying is the removal from lumber of all moisture, of whatever form, contained in its pores. The sap is not pure water, but contains many substances in solution. All the conifers contain resin. The sap of all trees contains albumen. The ideal effect in the drying process is produced by removing not only the liquid or volatile constituents of the sap, but also those chemical compositions—albumen, starch, sugar, etc.—which by absorbing moisture, after being once dried, may set up fermentation, the initial process of decay in wood.

To produce this ideal effect the drying must commence at the heart of the board and work outwards, the moisture being removed from the surface as fast as it exudes from the pores of the wood. The catalog describes the "moist air" process which fulfills this requirement. The surface of the lumber is kept soft, the pores being opened until all the moisture within has been volatilized by the heat and carried off by the strong circulation of the air. When the moisture is removed from the pores, the surface is dried without closing the pores, resulting in lumber that is clean, soft, bright, straight and absolutely free from stains, checks, or other imperfections.

The catalog describes two general types of moist air kilns. In one the air circulation is obtained by natural means and in the other by mechanical means or forced circulation.

For natural-circulation kilns the "progressive" type is first described which operates on what is known as the "progressive" principle, the green lumber, piled on cars, entering at one end of the kiln, and being gradually moved down through the kiln as the dry lumber is removed at the other end. When green lumber first enters the kiln it is not in a condition to stand a high temperature. For this reason the floor heating coils do not extend back to the green end. Therefore, when a car of lumber is run in, it enters an atmosphere moderately high in temperature and quite moist. Under such conditions the sap within the wood is thoroughly soaked, much the same as if the lumber had been steamed. The gentle heat surrounding it starts the sap toward the surface, the drying taking place first in the center of the board.

As the car moves forward it is gradually brought into a hotter and drier atmosphere. The effect is that the moisture in the surrounding air keeps the sugars, starch, albumen, etc., near the surface, in a semi-liquid state, until all the internal moisture has been extracted. The continually increasing temperature eventually draws the moisture from the pores near the surface, and the surface itself is finally finished off in a practically dry atmosphere.

The lumber entering the kiln does not stand over any steam pipes for several hours (which would cause case hardening), but it is subjected to a mild, moist heat, preparatory to entering a more intense heat and drier atmosphere when in a proper condition to endure it without injury.

The path of the air current is longitudinal, or from end to end, not up through the middle and down the side walls as in other kilns, which results in the same temperatures and humidity from one end to the other. The cold, wet cars at one end chill the air, causing it to drop down beneath the tracks. The heat generated at the other end by the steam coils creates a partial vacuum beneath the tracks, into which the air rushes from the other end and rising up through the lumber circulates toward the wet end, this operation being continuous.

While with the "progressive kiln" the operation is continuous, it discontinues with the "apartment type" of natural circulation kilns which are especially desirable when the stock used by the manufacturer is required in comparatively small quantities, of varying thicknesses, from a diversity of woods and in varying degrees of dryness.

The second part of the catalog deals with forced-circulation kilns. The forced circulation or blower dry kiln is probably the oldest type of modern kilns. This kiln is a greater success to-day than ever before. It will turn out just as good quality, in just as short a time, as any other type of kiln on the market, and with no greater expense for operation if properly handled. This kiln is recommended especially for drying bent stock, staves, heading, shingles, hoops, lath, tub and pail stock, and it is almost universally used in these particular lines. This kiln gives best results when it is operated on the "progressive" principle; that is, the green lumber pailed on cars, enters at one end of the kiln, and is gradually moved down through the kiln toward the blower and the heater, as the dry lumber is removed from that end. When the green lumber enters the kiln it is surrounded by an atmosphere impregnated with moisture gathered from the cars ahead, over all of which the air has passed, and is subjected to a temperature from twenty to forty degrees lower than it eventually has to withstand before leaving the kiln when finally dried. The sap within the wood is thoroughly soaked, much the same as it would be if first steamed, only the effect is milder and perfectly harmless.

The heat starts to volatilize the moisture within the pores, bringing it to the surface, where it is taken up by the air and carried off. In this way the drying takes place first in the center of the board, the dampness of the surrounding atmosphere keeping the pores open, thus preventing case hardening or checking. As the car moves forward it is gradually brought into a hotter and drier atmosphere. The continually increasing temperature, with a corresponding dryness, eventually removes all the moisture, the car finally standing directly over the duct where the air rises hot and dry.

Data are given in the catalog on details of the drying equipment (heating coils, etc.), on drying kilns specialties (structural steel rail supports, trucks, traps, temperature and humidity measuring instruments), and methods of loading dry-kiln trucks.

---

**Colorado metal production** for 1913 was valued by the U. S. Geological Survey at $35,449,298. The production of zinc and gold decreased, but silver, copper and lead increased, as compared with the previous year.

The metal production is itemized as follows: Gold, $18,146,916; silver, 9,325,255 oz.; lead, 87,620,364 lb.; copper, 7,298,269 lb., and zinc, 119,346,429 lb. Cripple Creek produced 60 per cent of the total gold yield in the state. Leadville produced 79 per cent of the zinc.

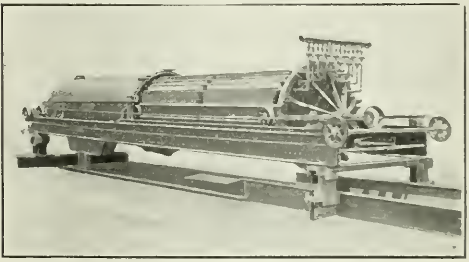
The number of the mines producing metals in 1913 was 858, of which 29 were placers, as against 856 mines, of which 33 were placers, in 1912.

## Filter Press Work in Cane Sugar Factories

Owing to the article descriptive of the Worthington filter press work in a cane sugar plant in Cuba, appearing in the July issue of this magazine, and in which certain comparisons were made with a "late type of cylinder press," we deem it only fair to publish the following article for which the Kelly Filter Press Company, of Salt Lake City, Utah, assumes full responsibility.

"The data for the so-called type of cylinder press was taken directly from page 26 of the Kelly Filter Press bulletin entitled 'Filtration Economy in All Industries,' and on account of the fact that the Kelly press is the only late type of cylinder press installed in cane sugar plants so far as can be determined, it is thought only fair to make correction in the article which appeared in the July issue of this paper.

"First and foremost, the data taken from the Kelly Filter Press bulletin was quoted incorrectly. In Table 2 of the article it was stated that the per cent of sucrose in the press cake dumped from the Kelly press was 8 per cent. *This should have been eight-tenths of 1 per cent.* The cake dumped from the Worthington press according to this article contained 6.85 per cent sucrose. In other words, 1 ton of cake dumped from the Kelly press contained 16 lb. sucrose, while 1 ton of cake dumped from the Worthington press contained 137 lb. of sucrose. The sugar saved by the Kelly press over the other type amounts to a very large saving, as a glance at the following will show.



KELLY FILTER PRESS IN SUGAR PLANT

"Assuming a cane sugar factory grinding 1000 tons of cane per twenty-four hours, and that in such a factory the weight of filter cake dumped approximates 1.5 per cent on the weight of cane crushed, there would be 15 tons of filter press cake dumped per twenty-four hours from plate and frame presses.

"In two separate tables in the previous article it was stated that the cake dumped from the Worthington press contained 6.85 per cent sucrose. This would be, therefore, 1.03 tons, or 2060 lb. of sucrose per twenty-four hours. An equivalent amount of cake dumped from the Kelly press contains only 0.8 per cent sucrose, which would equal approximately 0.2 ton, or 400 lb., of sucrose per twenty-four hours. The difference is 1660 lb. of sucrose in favor of the Kelly. Assuming that 92 per cent of this can be recovered as 96 deg. sugar, then 1527 lb. of sucrose is saved every twenty-four hours by Kelly filter-press methods. It will cost, say, ¼ cent per pound to make this into sugar. If sugar is worth 2¼ cents per pound, then we can figure the actual value of sugar per pound at this station at 2 cents. *This means a sucrose saving per day of* $30.54, which on a 200-day campaign would equal $6,104.

"It is in savings of this nature and magnitude by which the Kelly press has proven its worth as an efficient filter.

### Length of Cycle

"In the previous article in Table 2, it is stated that the average of the Worthington cycle is forty-five minutes and that of the Kelly press is 160 minutes. This gives an incorrect impression due to the fact that a period of wash was used in the Kelly press cycle, and evidently no wash was used in the cycle of the Worthington press.

"The cake dumped from the Worthington press per cycle is given at 179 lb., containing 58.42 per cent and 6.85 per cent sugar. The remaining portion of the cake would therefore represent 34.73 per cent of the weight which would be the dry insolubles. The amount of solids would therefore be 62 lb. per cycle. According to our data sheet, there are approximately 279 lb. of dry insolubles per cycle dumped from the Kelly press. The filter area of the Worthington press is given as 300 sq. ft., while that in the Kelly press is 420 sq. ft. This shows a capacity of 0.207 lb. of cake per square foot of filter area per cycle in the Worthington press, as against 0.66 lb. per square foot of filter area per cycle in the Kelly press.

"It seems to be a predominant opinion among cane sugar men that it is absolutely essential to have a washing machine in connection with the filter press department for washing the filter bags. We cannot emphasize too strongly the fact that we do not require a washing machine in connection with the Kelly press because the cloths are washed thoroughly inside of the press.

"The claim is made the same set of bags was used continuously until worn out. They are not removed from the press for washing. The permeability of the cloths is restored each cycle, thereby constantly maintaining high efficiency in the ratio of filtration of the cachaza.

"Another feature of the Kelly operation which we wish to emphasize is the fact that the sugar is washed out of the filter press cake directly in the press, and that such wash is practically perfect, the sugar being virtually pushed out of the cake in place; or, in other words, displaced directly with water. This means a minimum dilution of the sugar juices. It has been proven that this dilution is negligible as compared to that resulting from the addition of water to the cachaza before filter pressing, or the dilution accompanying the disintegration of filter cake with water followed by a secondary filtering operation, as sometimes practiced in connection with the plate and frame presses. The latter, we assume, is the method of obviating sucrose losses in the Worthington press.

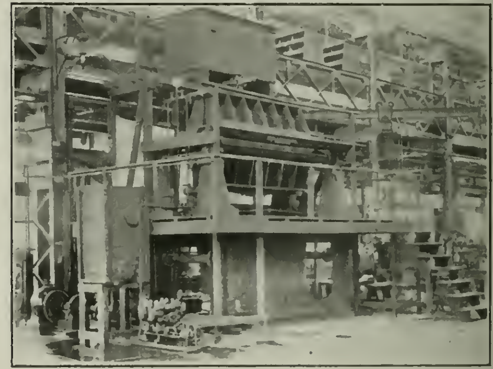
"We would be very glad to compare the brightness of the juices after filtration by the Kelly press; life of filter bags; labor required; the heat conserved; the leakage, breakage and maintenance costs and repairs with that obtained by any other filter apparatus on the market.

"The data above submitted for the operation of the Kelly press have been taken from tests made under the supervision of the chemist of the Adeline sugar factory where eight Kelly presses are installed. Those readers desiring more complete detail on the above data, may be referred to insert at page 26, of the Kelly Press Company's bulletin, which will be furnished upon request by that company."

**Materials of engineering construction** will be one of the subjects considered at the International Engineering Congress, 1915. Among the topics that will be covered will be timber preservation, clay products, concrete, special steel, copper and alloys, aluminum, and the testing of materials. Full information can be had from the Congress, Foxcroft Bldg., San Francisco.

## Filter Press Laboratory

In a recent issue we described the Worthington press as installed in a Cuban sugar central. It is to be noted that this invention and improvement is one that will materially aid this particular industry. The press is, however, suitable for many other purposes such as dewatering of slimes. Methods developed in this press bring out the possibility of handling colloids without the introduction of any unnecessary amount of sand, inasmuch as it does not force through the cake or the filtering medium, obviating closing of same. The use of this press in handling wool grease or sludge, as well as sewage and tankage, has been fully demonstrated and accomplished. Its importance in handling clay products rapidly and continuously has been proven. It is a self-contained construction with easy accessibility and gives many advantages, such as quick and efficient closing and opening for charging and discharging, quick dropping of cake by gravity, manual labor cut down to the smallest, and power consumption hardly any. Such simplification and easy manipulation, saving in filter cloth and greater recovery in either clear liquors or clean press cakes, gives an improvement that means reduction in cost of operation.



WORTHINGTON FILTER PRESS LABORATORY

The illustration shows the laboratory of Henry R. Worthington, Harrison, N. J., where a 6-ft. x 9-ft. press is in operation for experimental purposes, all completely fitted up with agitator tank, filling pipes, supply pump for material to be filtered and small pressure pump producing final squeeze. The press shown has automatic closing features operated by water pressure and self-dumping bag arrangement for dropping cake in a belt conveyor. There is maintained a complete chemical and experimental laboratory, where all filtration tests are made of material sent by prospective customers. They have a corps of efficient and practical filtration experts and engineers, who install and start these presses to get the best results.

**Brass-Furnace Practice** is the title of **Bulletin 73**, by H. M. Gillett, recently issued by the U. S. Bureau of Mines. It contains a report into the losses sustained in melting nonferrous alloys, which amount to about 5 per cent of the original metal. It is shown that from 90 per cent to 95 per cent of the heat units in fuel used in melting do no useful work. The financial saving to be effected by improved practice in melting, due to reduced loss of metal, increased efficiency of fuel and crucible life, is estimated to be about two million dollars.

## Hydraulic Reducing Valve

The adjoining illustrations show a new type of hydraulic reducing valve which the Auld Company, 1247 North 12th Street, Philadelphia, is just putting on the market. The illustration shows a 4-in. valve for an inlet pressure of 800 lb. and an outlet pressure of 500 lb. The construction of the valve is simple and all parts are strong enough to insure that it will give continuous and reliable service. The outlet pressure does not vary, though the volumes of water being passed through the valve may vary. The operation of the valve is as follows:

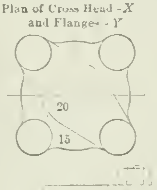
The initial pressure enters by the branch marked "inlet" and acts between the main valve 7 and the piston 4. The piston is of greater area than the valve 7 and therefore the main valve is held tightly shut on its seat 8. To prevent water from passing from the top to the bottom side of the main piston 4 a cup leather 6 is fitted.

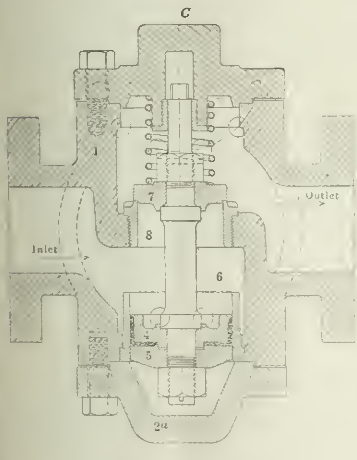
The initial pressure passes from the high-pressure side into the port $B^1$ which communicates with the space at the top side of the regulating valve 13. This regulating valve is held open by action of the spring 23 and the high pressure is allowed to pass through the valve 13 and down the pipe 22 into the chamber under the piston plate 5.

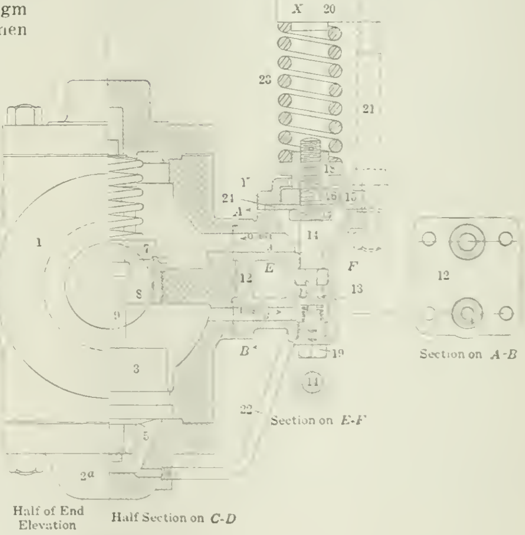
With high pressure acting on both sides of the piston 4, the valve 7 is forced open, due to the area of piston 4 being greater than the valve 7, and pressure flows into the outlet or low-pressure side. The low-pressure side of the main valve body 1 is connected to the diaphragm chamber of the regulating valve by port $A^1$ and when the pressure under the diaphragm acting on the area of the piston 16 exceeds the load which the spring 23 is set at it forces up piston 16 and valve 13 stopping the flow of water to the underside of the piston 4 (i.e., chamber under piston plate *S*) and allows the main valve 7 to come to its seat and stops the flow of pressure from the inlet side.

There is a constant leakage from the underside of piston 4 to the low-pressure side through the slots cut in the body of the regulating valve (shown at section on *EF*) and when the regulating valve 13 closes, the surplus water under the piston 4 is forced out through the pipe 22, through these slots into the diaphragm chamber and through the port $A^1$ into the low-pressure side of the main valve body. This action is repeated so long as the pressure on the outlet side tends to vary.

A slight variation of the outlet pressure is sufficient to operate the reducing valves and any fluctuations which take place are thereby rendered negligible.







HYDRAULIC REDUCING VALVE

## Personal

Dr. **Lucien I. Blake**, well known for his inventions in the field of electrostatic ore separation, is delivering a series of lectures on Cosmic Physics at the University of California. He will spend some time in Denver after concluding his engagement about August 1.

Dr. **Leo H. Baekeland**, of Yonkers, N. Y., started on July 11th on a trip around the world. He is now en route to Japan and Korea.

Mr. **Albert Burch** will have general management of the Aurora Consolidated mine and mill which was recently acquired by the Wingfield interests. He will retain also general management of the Goldfield Consolidated. Mr. **K. M. Simpson** has been made assistant general manager of the latter company.

Mr. **J. M. Callow**, of the General Engineering Co., Salt Lake City, Utah, is supervising the installation of the 200-ton experimental flotation plant for the Inspiration Consolidated Copper Co., Miami, Ariz.

Mr. **Fred Close**, metallurgical engineer of London, has returned from a professional trip to Alaska.

Mr. **J. V. N. Dorr** received the honorary degree of Mining Engineer at the recent commencement of Rutgers College, in recognition of his work in the metallurgy of gold and silver.

Mr. **R. C. Gemmell**, general manager of the Utah Copper Co., was chairman of the organization committee having in charge the establishment of a branch of the American Institute of Mining Engineers in Salt Lake City. The organization meeting was held August 13.

Mr. **W. G. Haldane**, acting president of the Colorado School of Mines, was granted the degree of Doctor of Science at the commencement exercises of Denver University.

Mr. **H. W. Hardinge** is on a business trip through Canada, Alaska and the western United States.

Mr. **D. C. Jackling**, managing director of the Utah and other copper companies, has returned from his Alaskan trip. He expects to go East for conference with his associates and will then return to Alaska.

Mr. **J. W. Jeffrey** was recently elected second vice-president of the Jeffrey Manufacturing Co., Columbus, O.

Mr. **C. D. Kaeding**, formerly assistant general manager for the Goldfield Consolidated Mines Co., Nevada, has been appointed vice-president and general manager for the Dome Mines Co., Ltd., at South Porcupine, Ontario.

Mr. **F. A. Kaufmann** has resigned his position with the Tottenville Copper Company and is now connected with the Roessler & Hasslacher Chemical Company at Perth Amboy, N. J., as chemical engineer.

Mr. **Guy M. Kerr**, formerly superintendent of the Arkansas Valley plant of the A. S. & R. Co., Leadville, Col., has been transferred to an executive position at the Garfield smelter, near Salt Lake City. He is succeeded at Leadville by Mr. **J. F. Austin**, formerly superintendent of the same company's plant at Monterey, Mexico.

Mr. **William D. Leonard** has been appointed superintendent of the Garfield Smelting Works, Garfield, Utah.

Mr. **Bernard MacDonald** has removed his office from Pasadena to 533 I. W. Hellman Bldg., Los Angeles, Cal.

Dr. **Harold Pender**, professor of electrical engineering at the Massachusetts Institute of Technology and director of the research division of the department of electrical engineering, has been invited to become professor-in-charge of the department of electrical engineering at the University of Pennsylvania, and has accepted this invitation, which will become effective next fall. Heretofore the departments of mechanical and electrical engineering at the University of Pennsylvania have been under the joint direction of the Whitney professor of dynamical engineering. From the beginning of next year the department of electrical engineering will be on an independent and coordinate footing with the departments of civil and mechanical engineering.

Dr. **Edward D. Peters** was given the honorary degree of Doctor in Engineering by the Royal School of Mines, Freiberg, Saxony.

Mr. **William C. Post** has resigned his position as metallurgical engineer with the Illinois Steel Co., and will take a similar position with the Jeffrey Manufacturing Co., Columbus, O.

Dr. **Rossiter W. Raymond** delivered the commencement address at the Colorado School of Mines. While in Denver he was the guest of honor at a dinner tendered by the local scientific and mining men.

Mr. **P. A. Robbins**, general manager for the Hollinger Gold Mines Co., Timmins, Ontario, has returned from a trip abroad and resumed his duties.

Prof. **Robert H. Richards** has been making a tour of the Western metallurgical centers gathering data on ore dressing. The itinerary includes Lake Superior, Montana, Idaho, California, Nevada and Utah.

Mr. **Robert C. Sticht**, general manager of the Mt. Lyell Mining & Railway Co., Tasmania, is on an extended vacation which will take him to Germany. On his trip through the United States he has visited the scenes of his former activities in smelting in Montana and Colorado. While in Denver, Mr. Sticht was the guest at a dinner given by the Colorado Scientific Society, of which he has been a member for over 30 years.

Mr. **L. C. Turnock** has resigned his position with the Pennsylvania State College as head of the Department of Electrochemical Engineering, which he has held for the past three years, and has accepted a position with the Edison Storage Battery Company in Orange, N. J.

## Obituary

We have been advised of the accidental death on June 29 of **Arthur Austin**, chief chemist for the International Smelting & Refining Co., at Tooele, Utah. He was engaged in testing work and had been experimenting with oil burners. A steel oil-container under high pressure exploded, covering him with oil which immediately caught fire. He was so severely burned that he died a few hours later. He leaves a widow and young child. He was a son of L. S. Austin, a graduate of the Colorado School of Mines, '05, and had been in the employ of the Anaconda Copper Mining Co. practically since his graduation. He was transferred to the Tooele works several years ago. In his work with these companies he had given excellent satisfaction, and showed promise of developing into a competent metallurgist.

**Benjamin F. Thomas**, of Chattanooga, Tenn., died in Atlantic City, N. J., on June 25, at the age of fifty-two years. He was ill only a few months, having suffered a stroke of paralysis in January. He was one of the founders of the Coca-Cola Company and president of the Coca-Cola Bottling Company. Mr. Thomas was interested in many departments of technical chemistry and will be remembered by our readers as a constant and jovial attendant at the meetings of the American Electrochemical Society.

## Notes

**A patented substitute for platinum** to be used for electrical contacts consists of an alloy of 45 per cent platinum, 15 per cent gold, 25 per cent silver and 15 per cent copper.

**Stratton's Independence, Ltd.**, Cripple Creek, Col., milled 11,800 tons of low-grade mine and dump ore in the month of May, 1914, yielded a net working profit to the company from both mine and mill departments of $10,150.

**Stamp duty on the Rand** is steadily increasing. In 1908 it was 6.27 tons per stamp in 24 hours. In 1909 it was 6.79; in 1910, 7.19; in 1911, 7.88; in 1912, 8.39; and in 1913, 8.82. It is anticipated that the duty for 1914 will average 9 tons or over.

**Transvaal Gold Production.**—The number of companies reporting to the Transvaal Chamber of Mines in April, 1914, was 60. The total quantity of ore milled during that period was 2,130,545 tons. There were 9695 stamps in operation, with an average duty of 8.85 tons per stamp in 24 hours. Tube mills in commission numbered 290. The yield for the month was 683,877 fine ounces of gold. Compared with the report of a year ago the current report shows 350 fewer stamps dropping, but 5 more tube mills in commission. The current yield is less than that of April, 1913, by 101,097 ounces gold. The yield per ton milled is about the same as a year ago.

**Steel Chain Belt.**—The Chain Belt Company, of Milwaukee, Wis., have issued their illustrated catalog No. 59 on Chabelco steel chain belt. This is an all-steel, case-hardened-bearing roller chain belt designed to meet the most difficult conditions. The side bars are punched from mild-steel bar stock. The rollers for transmission purposes are made of the best grade of cold-rolled steel shafting, machined out of the solid on automatic turret lathes. The rollers for elevating and conveying purposes are made of cold-rolled steel, cast steel or grey iron. The bushings are stamped out of cold-rolled pickled steel. The pins are made of forged steel and milled flat on ends to fit oblong hole in side bar to prevent turning. Every pin and bushing is case-hardened and heat-treated. Chabelco steel chain belt can be used by practically every industry for elevators and conveying and transmission purposes and has been introduced with particular success in pulp and paper mills, power houses, canning plants, cement mills, fertilizer plants, packing houses, ice plants, oil wells, sand and gravel plants, glass plants and potteries. Chabelco steel chain belt is also used on the same company's pivoted bucket systems of both overlapping and contact-lip type; the capacities of these systems range from 20 tons per hour up. A special study of methods for handling coal and ashes has also been made by the Chain Belt Company. The catalog is well illustrated and gives details of types, sizes and dimensions.

**Secondary metals recovered from waste and scrap**, exclusive of gold, silver, platinum and iron, in the United States in 1913, had a gross value of $72,845,000. After remelting and refining these secondary metals sell at only slightly lower prices than new metals. For purposes requiring metal of exceptional purity it is necessary to use virgin metal, but otherwise the secondary metals can be used in whole or in part. The use of magnetic separation in the recovery of secondary metals is on the increase. Following is a tabulation of secondary metal production, prepared by the U. S. Geological Survey:

*Production of Secondary Metals in the United States in 1912 and 1913*

| | 1912 | | 1913 | |
|---|---|---|---|---|
| Metal. | Short tons. | Value. | Short tons. | Value. |
| Secondary copper, including that in alloys other than brass .... | 66,441 | $21,593,325 | 66,980 | $20,536,068 |
| Remelted brass ....... | 101,523 | 27,279,516 | 99,315 | 24,651,969 |
| Secondary lead ....... | 30,266 | 6,045,120 | 33,104 | 6,409,392 |
| Recovered lead in alloys | 36,902 | | 39,730 | |
| Secondary spelter ..... | 32,251 | 7,750,491 | 50,005 | 6,019,776 |
| Recovered zinc in alloys other than brass .... | 3,912 | | 3,743 | |
| Secondary tin ........ | 8,333 | 14,301,368 | 6,415 | 12,567,379 |
| Recovered tin in alloys | 7,068 | | 7,763 | |
| Secondary antimony ... | 13 | 426,020 | 45 | 460,932 |
| Recovered antimony in alloys .............. | 2,493 | | 2,660 | |
| Secondary aluminum .. | ..... | ......... | 2,198 | 2,199,180 |
| Recovered aluminum in alloys .............. | ..... | ......... | 2,456 | |
| Total value ....... | | $77,395,843 | | $72,844,996 |

**The production of primary refined lead** in the United States in 1913 amounted 462,460 short tons, being a decrease of 18,434 tons, or 3.8 per cent., compared with the output of 1912. The production of secondary lead was 72,834 tons.

## Digest of Electrochemical U. S. Patents

PRIOR TO 1903.

*Arranged according to subject-matter and in chronological order.*

*Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.*

*Electroplating* (Continued)

453,355, June 2, 1891, Alexander Elliot Haswell and Arthur George Haswell, of Vienna, Austria-Hungary.

Relates to coating metals, such as iron or steel, with an anti-corrosive deposit of binoxide of lead or of a mixture of binoxide of lead with binoxide of manganese by means of a galvanic current. The bath contains one liter of water, eight to eighty grams of nitrate of lead and twenty to fifty grams of nitrate of ammonia. The article to be coated is connected to the positive pole of a source of current and immersed in said bath. In practice, good results have been obtained with a current strength of one-half ampere to one ampere per square decimeter surface of the article to be coated, and a tension of two volts to two and one-half volts. The temperature of the bath may vary from 64 deg. to 75 deg. Fahr. A suitable deposit is obtained in about ten minutes. To the above bath may be added about half a gram of nitrate of protoxide of manganese; this will give a deposit of binoxide of manganese along with the binoxide of lead.

476,639, June 7, 1892, Alexander Elliot Haswell and Arthur George Haswell, of Vienna, Austria-Hungary.

Relates to forming deposits of oxides on metals by electrolysis, and is an improvement on their earlier patent No. 453,355, dated June 2, 1891.

For preparing the improved bath, eighty grams of nitrate of lead are dissolved in five hundred grams of water and this solution poured into six hundred and thirty-five grams of caustic soda solution, having a specific gravity of 1.27, equal to 31 deg. B., and containing one hundred and fifty-eight grams caustic soda. After mixing ten grams of finely powdered carbonate of manganese are added and the bath well stirred during electrolysis. The article to be coated is connected to the positive pole and immersed in the bath. In practice, good results have been obtained with a current of one-half to one ampere per square decimeter of surface to be coated, and a tension of from two to two and one-half volts. The temperature of the bath may vary from 64 deg. to 75 deg. F. A deposit of suitable thickness may be obtained in about ten minutes.

509,124, November 21, 1893, Hannibal Goodwin, of Newark, N. J.

Relates to electro-etching of plates, etc., and describes several well-known methods of producing a design, etc., upon a plate by photographic means. The metal to be dissolved, or etched, is finally exposed, the plate suitably waxed and connected as an anode, and etched in any suitable electrolyte. A plate to be etched and a cathode are suspended in a cell, and connected in series to another plate and cathode in another cell, a number of such plates so connected are electrolyzed by a dynamo current, instead of electrolyzing plates separately by a battery current.

514,896, February 20, 1894, Craig Ritchie Arnold, of Sharon Hill, Pa.

Relates to processes of coating metals with oxides, the article to be coated being connected as anode in a solution of the metal to be deposited as oxide. For depositing peroxide of lead, the anode is immersed in a solution made as follows: to prepare twenty-two gallons, dissolve twenty-two pounds of nitrate of lead in seven gallons of hot water; this solution is poured into eleven gallons of caustic soda of 1.20 sp. gr., after having been warmed to 70 deg. C. After about thirty minutes, and when cool, sufficient water is added to bring it to the required volume. During plating, finely divided litharge is added to the solution, and thoroughly agitated. The cathode is placed in a porous cup containing a concentrated solution of caustic soda, either alone, or in combination with bichromate of soda; caustic soda is preferred, although bichromate of soda may be used as the equivalent.

517,275, March 27, 1894, Hannibal Goodwin, of Newark, N. J.

Relates to the decoration of gold or silver by electro-etching and oxidizing or depositing. A suitable design is applied to a gold or silver surface by any of the usual means; the gold or silver is then connected as an anode and suspended in a solution containing iodine, preferably potassium iodide containing free iodine. The electrolysis produces a quick and perfect etching of the unprotected parts of the plate without disintegrating the resisting matter applied for insulation. Since it is very difficult to apply a different color to gold by oxidation, patentee deposits silver upon the etched surface of the gold, and then oxidizes or platinizes the silver; or any other contrasting metal may be substituted for the silver.

526,114, September 18, 1894, Emile Placet and Joseph Bonnet, of Paris, France.

Relates to the electrodeposition of chromium, from aqueous and fused baths; also to the deposition of chromium alloys. For the aqueous solutions, chromic acid or a chromic salt is dissolved in water, to which may be added an acid, and also one or several of a plurality of substances which vary the tint of the deposited metal. For alloys, a salt of the metal to be added is dissolved in the electrolyte. The patent should be consulted for details.

534,259, February 19, 1895, Pompeo Garuti, of Florence, Italy.

Relates to an apparatus for the electrolysis of water, and preferably consists of a lead-lined tank in which is placed an inverted box-like compartment divided into a plurality of separate narrow cells by diaphragms. Anodes and cathodes are placed in alternate cells, the tops of the latter having openings or vents to permit the oxygen or hydrogen to pass into collecting tubes. The electrolyte is preferably pure water containing twelve per cent. of its weight of commercial sulfuric acid of 60 deg. With an acid electrolyte, it is preferred to make the entire apparatus of lead. Instead of acid, a 15 per cent solution of caustic soda or potash may be used, in which case the apparatus may be made of cast or wrought iron, or steel.

534,895, February 26, 1895, William H. Legate, of Hartford, Conn.

Relates to a method of and apparatus for marking and ornamenting tableware, such as knives, etc., and other articles. The article to be marked is coated with a suitable varnish; a metal stamp bearing the design to be imprinted is moistened with strong potash solution and pressed against the varnished surface. The potash dissolves the varnish, exposing the metal in the outline of the design; the article is now washed with water, and then in solution of ammonium chloride is applied to the exposed metal. The knife or other article is now connected as an anode, and the metal stamp as cathode; the electric current etching the article and fixing the mark or design. The article is then washed in potash to remove the varnish, and may be further treated as desired. The apparatus consists of a frame to hold a pluarility of knives, etc., and a plurality of metal stamps, in fixed relation to each other.

*(To be continued)*

## Book Reviews.

**Organometallic Compounds of Zinc and Magnesium. By Henry Wren, Ph.D.,** 12mo. (12 x 15.5 cm.), 100 pages; price $0.75 net. New York: D. Van Nostrand Company.

A monograph which will give the organic chemist a good résumé of the Grignard reactions with magnesium salts and the corresponding zinc salt reactions. It is particularly concerned with the use of these reactions as intermediaries in isolating difficult organic compounds. It has practically no interest for the metallurgist or electrochemist, since the properties of these organic metallic compounds are scarcely mentioned, and their possible uses in and of themselves ignored. The illuminating and suggestive book on organic-metallic compounds has yet to be written.

* * *

**The American Fertilizer Hand Book.**—Seventh Annual Edition: 1914. 456 pages. Price, $1.00. Philadelphia, Pa.: Ware Bros. Company.

The 1914 edition of the well known and useful annual Fertilizer Hand Book contains the usual statistical matter, brought up to date, on the fertilizer trade, the cotton seed oil industry, packing and rendering plants, etc., together with a number of specially prepared annual reviews. Among these we note the following: "The Sulphuric Acid Industry," by Andrew M. Fairlie; "Available Phosphates by Furnace Treatment," by James H. Payne; "Available Nitrogen in Compounds," by E. P. Verner; "Present State of the Cyanamid Industry," by E. J. Pranke; "The World-Wide Search for Potash," by Harry Wilson; "Mining of Florida Pebble Phosphate Rock," by Thomas M. Peters; "The Products of Cottonseed," by Thos. C. Law; "The Use of Packing-House By-Products," by J. B. Sardy.

* * *

**The Rolling Mill Industry. By F. H. Kindl, Engineer.** Octavo, 76 pages, 27 illus. Price, cloth binding, $2; flexible leather, $3. Cleveland, Ohio: The Penton Publishing Company.

According to the title page, this is "a condensed general description of iron and steel rolling mills and their products," and according to page 1, the author has in view to furnish those engaged in the iron and steel business with "a comprehensive knowledge pertaining to this important branch of the iron and steel industry."

The book fails absolutely in its avowed purposes. It is written as if for children under ten years old. The German word "*kindlich*" describes it exactly—with apologies to the author for borrowing his name to describe his book.

* * *

**Electric Furnaces for Making Iron and Steel. By Dorsey A. Lyon and Robert M. Keeney.** 142 pages, 36 illustrations. Bulletin 67 of Bureau of Mines, Washington, D. C.

This pamphlet of the Bureau of Mines is an excellent and timely summary of the history of electric iron ore reduction and electric steel refining and of the present status of the art. The first chapter, by Dorsey A. Lyon (p. 7 to 57), deals with the electric furnace in pig iron manufacture; the second chapter, by Robert M. Keeney (p. 58 to 137), with the electric furnace in steel manufacture. All furnace designs which have achieved any importance are concisely described and illustrated, together with a few typical installations. Some figures of cost are added. This is a decidedly useful piece of work of the Bureau of Mines.

# Metallurgical and Chemical Engineering

A Consolidation of ELECTROCHEMICAL AND METALLURGICAL INDUSTRY and IRON AND STEEL MAGAZINE

VOL. XII | NEW YORK, SEPTEMBER, 1914 | NO. 9

PUBLISHED MONTHLY BY THE
McGraw Publishing Company, Inc.
JAMES H. MCGRAW, President.
C. E. WHITTLESEY, Secretary.
JOHN T. DE MOTT, Treasurer.
239 West 39th Street, New York.
TELEPHONE CALL, 4700 BRYANT.
CABLE ADDRESS, METCHEM, NEW YORK.

ROCKY MOUNTAIN OFFICE........421 Boston Bldg., Denver, Colo.
PACIFIC COAST OFFICE......502 Rialto Bldg., San Francisco, Cal.
CHICAGO OFFICE............................Old Colony Building
PHILADELPHIA OFFICE................Real Estate Trust Building
LONDON OFFICE.............Hastings House, Norfolk St., Strand

E. F. ROEBER, PH.D., Editor.
H. C. PARMELEE, Western Editor.

J. M. MUIR, Manager.

*Yearly subscription price for United States, Mexico and United States dependencies,* $2.00; *for all other countries,* $2.50. (*European exchange,* 10 *shillings,* 10 *marks,* 12.50 *francs.*)

Copyright, 1914, by the McGraw Publishing Company, Inc.

Entered as Second-Class Matter at the Post Office at New York, N. Y., under the Act of Congress, March 3, 1879.

NEW YORK, SEPTEMBER, 1914

EDITORIAL:
- The European War........................................ 545
- As Seen After Twenty Years................................ 546
- Scrap and Finished Steel Products........................ 547

READERS' VIEWS AND COMMENTS:
- Electrolytic Zinc. By R. Molstad........................ 548
- Is There a Complex Ore Problem? By Lewis B. Skinner and H. Motherwell........................ 548
- Cost Accounting as a Branch of Accounting and the Work of Accountants. By Ernest G. Oshby........................ 549

Toronto Meeting of American Chemical Society Postponed.... 550
The European War and the American Chemical Industries. Interviews with Wm. H. Nichols, M. Toch, W. J. Matheson, B. C. Hesse and L. J. Matos........................ 551
The Iron and Steel Market........................ 554
The Western Metallurgical Field........................ 555
Some Aspects of Industrial Chemistry. By L. H. Baekeland. 557
Cyanide Practice in the Porcupine District, Ont., Can.—I. By H. C. Parmelee........................ 567
Refractometry. By G. A. Shook........................ 572
Titanium Nitride in Steel. By George F. Comstock.......... 577
The Electric Arc Furnace and the Development of the Steel Casting Industry. By Ivar Rennerfelt........................ 581
Goslar Convention of the Association of German Metallurgists 583
Some Economic Aspects of Industrial Chemistry. By B. C. Hesse........................ 584
Features in Work of Bureau of Standards........................ 588
Program of Chicago Meeting of the American Institute of Metals........................ 588
Utah Meeting of American Institute of Mining Engineers. Report and Abstracts of Papers on Copper Leaching........ 589
SYNOPSIS OF RECENT CHEMICAL AND METALLURGICAL LITERATURE........................ 594
NOTES ON CHEMISTRY AND METALLURGY IN GREAT BRITAIN... 597
Concentrating Unsized or Unclassified Ore-Pulp............ 600
The Application of Cold, Cleaned Producer Gas to High-Temperature Regenerative Furnaces........................ 601
Bakelite for Commulative Insulation........................ 603
A Fume and Smoke Recorder, Monitor, and Precipitator, and an Instantaneous Thermostat. By W. W. Strong........ 604
Electric Steel for the French Army and Navy............ 605
Suspension Type Storage Bins........................ 605
An Adiabatic Calorimeter........................ 606
The Metal Spray Process........................ 607
Vitreosil........................ 608
Niagara Falls Meeting of American Electrochemical Society. 608
PERSONAL........................ 609
DIGEST OF ELECTROCHEMICAL U. S. PATENTS (Electroplating). 609
BOOK REVIEWS........................ 610

## The European War

War is hell. Our knowledge of what is happening on the other side of the Atlantic comes to us through a rapid sequence of extra-editions of newspapers and while this highly excitable moving picture show of glaring headlines, more or less contradictory, passes before our eyes, we see only one thing clearly—that a gigantic calamity has come over Europe—and we pause quietly to ask why this whole terrible thing is going on.

Have men whom we have known intimately for years and have admired for their peaceful achievements in arts and sciences, suddenly gone crazy? Have practically all Europeans suddenly gone crazy? If we want to avoid this conclusion, nothing is left but the inference that the psychology of nations is different from the psychology of individuals.

Nor is this inference unwarranted. We know that an individual acts differently in a crowd than when left to himself. We know that we may be impressed quite differently by a silver-tongued orator if we hear him in the midst of a sympathetic crowd than when we read his sophisms in the quiet of our home. And when in the past the Devil wanted to try a particularly interesting human reaction, he created a boom in a mining camp. Mark Twain has sketched vividly how the actions of otherwise perfectly sensible and normal men become abnormal in a mining boom. The fact is that when crowd psychology of which national psychology is a variety, gets the best of individual psychology, the "free will" of the individual is gone; there remains not much more of it than the "mean free path" of an atom. Crowds and nations then act under the blind forces of Nature. In the gigantic human reaction which the European war represents, the most celebrated individualities do not seem to have much more freedom of will than the "free" ions of the dissociation theory. And this is the most terrible thing in the situation, because if it is so, it means that the thing must go on to its most brutally complete conclusion.

There are clear-cut reversible chemical reactions. The European war is nothing of the kind. It is irreversible in all its phases and it is a horrid melee of half a dozen or more human reactions so that we cannot say which are primary or secondary—the hatred of race against race or commercial rivalry and envy or a revenge idea or an excess of militaristic autocracy or what else. We only know with absolute certainty that because it is an irreversible reaction its outcome is determined by the second principle of thermodynamics. Whatever may be the detailed result of the war for this or that country or nation, in the whole there must be a frightful increase of entropy. That is, European civilization as a whole must be reduced from a place in the sun to a temperature much nearer absolute zero.

* * *

The more carefully these reactions are restricted to Europe as an isolated system, the better for the rest of the world. President Wilson has been happy in defining the function of this country. There is no cause for alarm, but an opportunity for this nation to reap great permanent glory provided nobody loses his head. Our opportunity does not lie in war but in a control which will fit us, above of all nations of the world, to act for peace when the time comes.

How greatly this country is affected by the European war, is clearly evident in the situation of the metallurgical industries. We may simply look at the two extremes, copper and zinc, the former being hit hard, the latter being benefited by the war.

Half the copper output of this country has been exported in the past. Accordingly the copper production of this country has been cut in half by mines and refineries. While this was undoubtedly the wisest thing to do it means an irrecoverable loss of interest on half the plant investment.

On the other hand, zinc has been put in an enviable position by the fact that the zinc smelting centers of continental Europe are in the zone of war operations. Liege has been for zinc what Pittsburgh is for iron. Our opportunity to export zinc and galvanized iron products to South America is evident. The opportunity of electric zinc smelting is also clear. Our friend, Woolsey McA. Johnson, the American pioneer in this field, has been a brilliant writer on the subject and a clever experimenter in the past. The psychological moment has come for him and his people to deliver the goods in their projected plant at Keokuk.

As to the effects of the European war on the chemical industries of this country, the President's safe and sane advice—to keep a level head on our shoulders—is also the keynote of our interview with Dr. William H. Nichols published elsewhere in this issue.

If American chemists follow this advice, there is a great mission ahead of them. It would seem that the primary endeavor of the American chemical industry should not be so much a search for new markets (though this side of the situation should not be neglected), but a vigorous effort to assist general industry in this country to accommodate itself to the changed conditions. The substitution of glucose for sugar for part of its uses and other instances mentioned by Dr. Nichols show the possibilities ahead of the American chemists.

What enormous adaptations will have to be made in the way of using other materials or means to replace those no longer at the disposal of home industries, it is even yet very difficult to discern. But unless the chemical industry throws its whole efforts into the co-operation, it will find in the already threatening restriction of general industry its own bitter retribution.

On the other hand, the industries consuming chemicals must also keep a cool head. Already there has been too much buying; and even in products in which there is no reason to anticipate the slightest shortage, ignorant and thoughtless attempts to lay in unnecessarily large stocks have resulted in absurd increases of prices.

In other cases it will be necessary to recognize and provide for the total impossibility to obtain certain products on which our industries have come to rely, and it becomes essential to search for substitutes. Naturally those industries which have already provided themselves with chemical staffs and research facilities will be the most successful in finding quickly substitutes or developing means of doing without altogether.

It is, however, unfortunately to be feared that a very large number of lines of manufacture will probably have to depend upon the chemical industry for advice and technical assistance. Though we are confident that this assistance and advice will be cheerfully and even enthusiastically given, it surely will in many cases look like heaping coals of fire on heads which have too often treated the chemical industries of this country with scant consideration.

## As Seen After Twenty Years

A prominent metallurgical engineer visiting this country after an absence of almost twenty years said to us recently that one of the great changes he observed in his travel through the United States was the frankness of metallurgists in discussing their technical problems, and their generosity in making public the data on experimental and routine work. The former reticence, noticeable twenty years ago, has almost disappeared. The empirical "secrets of the trade" are no longer valuable, having been displaced largely by exact technical knowledge and skill. As we have advanced beyond the "muscular metallurgy" of the early days of smelting, so have we broadened our conception of self-interest to embrace the welfare and progress of our neighbor.

Another change observed by our visitor, in marked contrast to conditions two decades ago, is the great increase in the number of trained workers in our metallurgical works, and the moral and financial support given to experimental and research work by operating concerns. To-day technical graduates are found in many positions formerly held by untrained men. The foreman or boss of twenty years ago, whose chief claim to ability and distinction in many cases was physical prowess, is now supplanted by the "educated cuss" who, if physically less awe-inspiring and commanding, is mentally abler to relieve his superiors of attention to technical details. And so on down the line.

A third observation of favorable comparison between present and former conditions in the metallurgical industry is the growth in size and influence of technical societies, and the service rendered to the profession by engineering magazines. Owing to world-wide facilities for communication and dissemination of knowledge, this is a feature of our progress easily appreciated by our visitor without making a trip to scenes of former activity. Returning after many years spent in a foreign land, he finds that through such agencies, particularly those of the United States, he has been able to overcome the possible handicap of isolation.

It would be difficult indeed wholly to separate cause from effect in this wonderful change and improvement. Schools, societies and magazines have stimulated improvement and encouraged progress; at the same time they have been beneficiaries of the conditions they sought to create. Encouraged by the prospect of employment in a dignified and honorable profession, young men have crowded our schools of mining and metallurgy, later joining the great body of engineers who simultaneously support and receive inspiration from technical societies and magazines. The proud eminence which American metallurgy holds to-day is broadly the result of action and reaction among these great co-operating influences.

## Scrap and Finished Steel Production

At intervals since early in the year statistics of production in the various branches of the steel industry in 1913 have been returned by the Bureau of Statistics of the American Iron and Steel Institute and have been discussed in these columns. In the past month the last of the 1913 statistics have appeared, detailing the production of bars, skelp, nail plate, etc., and permitting a statement of the total rolled steel output for the year. The presentation is of interest by reason of the comparison that can be made with the total production of steel ingotts, showing the loss in manufacture and thus indicating approximately the amount of scrap resulting. The statistics of rolled steel are complete, covering the weight of material after the last hot rolling operation (with shearing), and thus taking cognizance of rods rather than of rod billets or drawn wire, black plates rather than either tin plate or sheet bars, skelp rather than welded pipe, and so on. Rolled forging billets and exported blooms, billets, sheet bars, etc., are included, as otherwise the material involved would be lost to the statistics.

The statistics of the production of steel ingots (excluding castings) and of rolled steel, together with the difference and the percentage the difference constituted of the ingot tonnage, are shown in the table below, for the past four years, in gross tons:

| | Steel ingots. | Rolled steel. | Difference. | Per cent. |
|---|---|---|---|---|
| 1910.... | 25,154,087 | 20,939,353 | 4,214,734 | 16.4 |
| 1911.... | 23,029,479 | 17,812,823 | 5,216,656 | 22.6 |
| 1912.... | 30,284,682 | 23,019,259 | 7,265,423 | 24.0 |
| 1913.... | 30,280,130 | 23,112,986 | 7,167,144 | 23.7 |

The sharp increase in the difference between ingot and rolled steel tonnage is remarkable and is probably attributable to a variety of causes, the proportionately greater increase in the production of steel involving many rollings, sheets, and black plates, for instance, as compared with rails, deeper cropping for the purpose of producing sound steel, and perhaps a definite desire upon the part of the steel makers to produce scrap for the open-hearth.

The experience of the past two years may be taken as representative of present-day practice, a loss of 24 per cent in weight from the ingot to the rolled steel. Part of this loss is scale, but by far the greater part is scrap. Very nearly all the scrap passes at once to the open-hearth furnace, to be used again in the production of steel ingots. A small part, doubtless, goes to steel furnaces for the production of castings, but as the production of open-hearth castings was only 910,216 tons in 1913 this item is relatively unimportant. On the other hand, there is new scrap produced in the fabrication of rolled steel, as in pipe mills, structural shops, etc. Estimating as closely as possible, but still roughly, the various additions and deductions, one may conclude that in 1913 about 6,500,000 tons of new steel scrap, produced in steel rolling mills, pipe mills, fabricating shops, etc., found its way into acid and basic open-hearth steel furnaces for the production of steel ingots.

We have statistics of the production of basic pig iron, practically all of this material passing to the basic open-hearth steel furnace, but no corresponding statistics of the production of pig iron for the acid open-hearth furnace, hence no comparison can be made of scrap and pig iron for the open-hearth industry as a whole. On the assumption that proportions were the same, an assumption that can lead to no serious error on account of the relatively small tonnages excluded, it may be concluded that in the production of basic open-hearth steel ingots about 6,250,000 tons of new steel scrap was employed, while the consumption of basic pig iron was about 12,250,000 tons. The production of basic open-hearth steel ingots was 19,884,465 tons, leaving a difference of 1,384,465 tons. This difference represents the consumption of old iron and steel scrap and casting pit scrap, plus the ferric gains through ore additions to the bath, minus slag and other losses. The consumption of old scrap is seen to be quite small relative to the consumption of new scrap, a fact which is not universally recognized outside the steel mill. It will be understood, of course, that the proportions vary widely in different plants. At the duplex works the consumption of old material is very small, while in detached open-hearth steel works, using purchased (cold) pig iron the consumption of old material is quite large. The commonest operation, in point of tonnage, is that of combined open-hearth and Bessemer operations, in which the open-hearth furnace receives not only the scrap produced in rolling the steel it produces, but also the Bessemer scrap arising.

As the production of Bessemer steel has declined the proportion of new scrap available for the open-hearth furnace is necessarily reduced. In 1907 the production of Bessemer ingots exceeded that of open-hearth ingots by 7.5 per cent, but in 1913 open-hearth exceeded Bessemer by almost 120 per cent. There is some evidence, as indicated, that cropping has been more liberal in the past two years than formerly, and this helps to keep up the scrap supply. More recourse is had, in addition, to the duplex process, which does not need scrap badly, but the final liquidation is in increased proportions of pig iron to steel ingots produced, a fact to which reference was made in our August number, it being there estimated that, excluding the duplex steel branch, the consumption of basic pig iron was 54.8 per cent of the steel produced in 1912, and 56.9 per cent in 1913.

# Readers' Views and Comments

## Electrolytic Zinc

*To the Editor of Metallurgical & Chemical Engineering:*

Sir:—With regard to your note on the "Borchgrevink electrolytic process for the treatment of zinc ores" in your June issue (page 381) I beg to remark that the invention was not made by Mr. Borchgrevink, but was worked out by the undersigned during a study-trip in Germany. Later on the expenses, with an experimental installation, have been paid for by Mr. Borchgrevink.

If the necessary capital can be procured, the intention is in the autumn to start a greater experimental plant with a capacity of about 85 tons a day.

In this electrolytic process an anode is used which was invented by myself with a special fit-up, which prevents the formation of roughnesses and trees on the zinc. The patent is taken out in Mr. Borchgrevink's and my own name.

R. MOLSTAD.

Christiania, Norway.

## Is There a Complex Ore Problem?

*To the Editor of Metallurgical & Chemical Engineering:*

Sir—In your August issue, page 490, Mr. W. Motherwell criticizes the following remark made by me in your June issue:

"In passing, as there are fads in metallurgical lines as well as in others, I might note that we are going through a stage when the whole fraternity is on the qui vive trying to make every ore amenable to treatment by some flotation process. In the case of one-mineral separation in the United States this process has proven an aid; but it is of no benefit in the case of ores of zinc, which are truly complex, although being advocated for such. I do not know of any complex ore in Colorado, for instance, that could possibly show any advantage under this treatment."

His second paragraph brings out what he imagines is a surprise in that there are four flotation processes used in Australia.

In the third paragraph he states: "It might be worth while to have some experiments made with it," this latter statement referring to Colorado complex ore.

In the fourth paragraph he calls attention to the so-called selective flotation process.

In making the statement shown in his first paragraph I did so advisedly, proof being that only those ventures are a success with flotation which have a one-mineral separation, notably, the Butte & Superior Copper Company and the Elm Orlu at Butte, and a plant down in the Platte River country, Missouri. Of course, there are incidentally small amounts of other than the main sulphides obtained in separation, but these amounts of minerals are not quantitatively sufficient to cause annoyance.

As to his second paragraph, I was well aware of the work that has been done in Australia, as is everyone engaged in the metallurgical field. I referred in my statement only to the work done in the United States.

There is no question but that flotation will be used on the copper porphyries to separate a small amount of mineral from a large amount of gangue and will be used as an adjunct in some large plants having a large percentage of gangue and a small percentage of mineral, notably on the slime product which is a result of crushing, the tonnages here being sufficiently large to permit of one demand of the process—that there is a large enough tonnage to work upon for financial success.

Regarding Mr. Motherwell's third paragraph, I would say that I already have the proof and he admits that he has not. However, to gain his point he must present some facts which are other than surmises. Incidentally I have had the privilege of running thousands of tons of the class of ore mentioned. Our ores, as a rule, are rather coarsely crystalline so that it is not a difficult matter to make a proper separation by ordinary mechanical means, and incidentally I would also say that such ores do not have a large percentage of gangue.

Further, there have been at least two plants in Colorado which have been built to operate by some flotation process, these being more or less experimental on a large scale. There is no tonnage of a smelting grade of zinc blende being produced by either operation and yet the experiments have cost, no doubt, a sum of money sufficiently large to be noticeable.

I myself have had to do with some experimenting on Colorado ores and ores from other states and so far have found it advisable on the truly complex ores to only recommend the flotation process as a subsidiary to the other general operations, that is, where the tonnage is sufficiently large to furnish an amount of suitable material for such operation.

With respect to Mr. Motherwell's fourth paragraph, it would seem as if up to date this selective flotation process was a matter requiring "fine-haired" operating efficiency and also would be very expensive, in which case, by comparison, it would not return as great a net profit to the mine, no doubt, as the ordinary older means of mechanical separation.

Since the proofs of my statements are evident and since Mr. Motherwell does not even admit familiarity with the situation, I would suggest that he furnish proofs against my statements. Otherwise there is no argument.

LEWIS B. SKINNER.

Denver, Colo.

* * *

*To the Editor of Metallurgical & Chemical Engineering:*

Sir:—Since writing you on this subject I have found time to read Mr. Ionides' contribution in your June issue. He speaks of an ore containing about 5 oz. Ag. per ton, 14.5 per cent Pb., 13 per cent Zn. and 0.25 per cent Cu., and refers to the heavy penalty exacted by the smelters for the zinc.

Assuming the lead and zinc to be in the form of sulphide, any person who would send this kind of ore to a smelter deserves all he gets. The flotation process will, by itself or in conjunction with mechanical concentrators, give him two separate marketable concentrates—one containing the lead and the other the zinc.

The assay given above represents roughly the value of the sulphide ore now being mined at Broken Hill, and not a ton of it is smelted in the crude state, and has not been for at least fifteen years. Before the flotation processes were used on a commercial scale, ten years ago, the ore was concentrated by jigs, tables and vanners, the lead and some of the silver recovered, and the tailing containing the zinc and some lead and silver was accumulated pending discovery of a method of treatment.

I should perhaps have explained in my previous letter that the complexity of Broken Hill ore arises, not so much from its metal contents, as from the nature of the gangue which is largely composed of rhodonite and garnet, which have about the same specific gravity as blende.

Further on, Mr. Ionides says: "No instance is known to me where high recoveries of all metals are made from an ore containing lead and zinc, copper and zinc, or all three." At the Broken Hill South mine during the second half of 1913 (according to the *Mining and Scientific Press* of May 9, 1914), the total extraction was 91 per cent lead, 85.6 per cent silver, and 84.2 per cent of the zinc. What has Mr. Ionides to say to that? The recoveries at some other Broken Hill mines (Proprietary, North and Central) are about the same.

He also says "the shine product from a lead or copper ore certainly is refractory." This was true ten years ago, but to-day nothing is easier. The same may be said of his remark that "the presence of zinc in an ore gives trouble all the way down the line, and if recovered with the lead it becomes a liability and not an asset."

His objection that flotation will not separate two minerals, I have already answered in my previous letter.

It appears to me that the possibilities of flotation are not fully realized in this country.

W. MOTHERWELL.

Humboldt, Arizona.

* * *

*To the Editor of Metallurgical & Chemical Engineering:*

SIR:—If we admit that the fine-grained ores composed of lead, zinc, and copper sulphides which have hitherto not been successfully treated on a commercial basis—excepting for the recovery of one metal—are "complex" ores, then there *is* a complex ore problem.

Some few years ago I went down to Cardigaushire, Wales, to examine a concentrating mill and tailings from same and ore from the mine. I found stacked a quite big pile of "seconds" from the tables which assayed Cu 7.5, Pb 11.8, Zn 25.5, Fe 9.9, S 28.5, CaO 5.6. The CaO was due to calcite gangue. There was no complex ore here, however, as in the mine a hand separation could have been made. I sampled a 6-in. vein of blend carrying 64.5 per cent Zn and the Pb occurred as 3-in. vein pure galena. The copper and iron were associated.

Such ores as of the Hercules-McRead district of Tasmania I would call "complex" and their successful treatment still awaits solution. Typical "Hercules" sulphide ore from No. 5 level: Cu 0.3, Pb 10 per cent to 12 per cent, Zn 26 per cent to 30 per cent, Fe 11 per cent, Mn 1.5 per cent, S 30 per cent, insoluble 10 per cent.

A really fine example of an ore worthy of the name "complex" is to be found in that probably forgotten mine, "Lake George," N. S. W., where such brilliant smelting work was done in 1899 by A. W. Hudson, now in Douglas, Arizona, a 27 per cent copper matte at first fusion being made from an ore under 2 per cent copper. At the 400-ft., 500-ft. and 600-ft. levels the ore body is about 40 ft. wide and every pound of it goes to the smelter. It is one of those close-grained sulphide ores in which no distinguishable minerals are visible. A government analysis of the 400-ft. level ore gives: Cu 1.1 per cent, Pb 8.0, Zn 14.5, Fe 17.7, $SiO_2$ 23.7, CaO 0.4, MgO 0.65, Pb $So_4$ 0.32.

My analysis of the "bulk ore" as sent to the furnaces towards the end of the smelting campaign runs: Cu 1.25 per cent, Pb 9.7, Zn 13.2 Fe 22.2 $SiO_2 + Al_2O_3$ 21.5, CaO 1.6, S 29.5.

This was sweetened up with some ores from upper levels and adjoining mines, one example being Cu 5, Pb 11.5, Zn 18.6, Fe 15.7, insoluble 17.2, CaO 0.5, S 29.5. There is a chance for the lead and zinc experts.

As other examples of what may be called complex ores I would mention those of the Conrad district of New South Wales, Bethanga and Cassillis districts of Victoria and the Oonah of Tasmania.

Mention of the Lake George mines reminds me in view of the present boom in leaching and recovery by scrap iron that it may not be known that as far back as 1899 many tons of copper were recovered from this mine from mine water. A much greater recovery might have been made had the management been awake, but the chemist's importunities were futile until backed up by threatened action for the loss of a cow that died from drinking the water 1 mile below the mine; and also a general outcry from the inhabitants of the township, whose water supply—drawn from wells sunk near the creek—gave a pale green shade to all clothes on washing day. That water carried 250 gr. per gallon.

H. MOTHERWELL.

Inspiration Cons. Copper Co.,
Miami, Arizona.

## Cost Accounting as a Branch of Accounting, and the Work of Accountants

*To the Editor of Metallurgical & Chemical Engineering:*

SIR:—Mr. Justin H. Haynes' article in your July issue regarding unit cost keeping in metallurgical work is deeply interesting. He emphasizes "that the cost statistics and cost sheet are a comparative guide to the maintenance of efficiency in a plant controlled or supervised by any executive."

This is the traditional and accepted definition of a cost sheet, and accountants universally are striving with considerable measure of success to make it so, and to make the figures that are placed thereon the true and actual showing for any period under review.

As I am in opposition to Mr. Haynes, as to who should draw up costs accounts, I would like to place before him through the pages of your paper Cost Accounting from the Accountant's standpoint and to show the necessity to *both the operator* and the administration, of the cost accounts and the fiscal books being in unison. This I will try and do, also endeavoring to convince him that the accountant is the most necessary friend of the operator, both in translating his desires and in placing before him those figures and statements which will furnish him with all the true figures that are requested of him, and which will also be in perfect harmony with the financial section of the company's books.

My views are:

Cost-accounting records, though perhaps only indirectly related to bookkeeping records, must be founded on ordinary double-entry principles. It may be sufficient for the financial records to show the total amount of the payroll, for example, whilst for the superintendent's cost sheet this item on the financial books will have to be dissected, and in consequence of obtaining this dissection from the financial records it will be a detail of these financial records. In other words the cost accounts must be in concord with the financial records, if for no other reason than the double check it affords both systems (and in consequence the greater security the operating man can feel in reviewing his figures).

Further cost keeping must be part and parcel of the whole accounting system for the reason that both use data that are alive in both. For whilst financial bookkeeping generally considers the operations of an organization, cost accounting considers the operations in detail. Both have to do with resources, liabilities, receipts, disbursements, losses and gains. And the fact that all these headings enter into both cost accounting and financial book-keeping, and that the former will have to look to the latter for its division of same shows only more clearly that it is impossible to draw any distinct line between them. They are an entity.

The man to advise and install a system of cost accounts should be a technical statistician who understands and studies the requirements and methods of manufacturing, etc. This the members of the accounting profession are rapidly becoming more and more to be.

In this installation, accountants readily recognize that it is most necessary for the cost systematizer to cooperate with the engineer if an efficient and practical cost system is to result. Obviously a superintendent knows along what lines he wishes information, and as the results are of primary importance to the engineer, that person should suggest these lines; but the accountant is the better suited to determine the means, the procedure and forms in connection with acquiring these data, as well as of distributing and segregating same, inasmuch as it is the accounting profession and not the engineering profession that has concerned itself with the study of cost systems together with their many deep and vexed problems (operating expense burden being an example). This study of cost accounting by accountants has not been given for the purpose of giving information to directors (excepting where a problem of cost accounting attaches itself to the desire of directors to test the efficiency of the superintendent or his subordinates), but for the purpose of giving the superintendent the benefit of a more scientific interpretation of the proper division and application of certain facts.

I would lay strong stress on the parenthesis above, to draw out the fact that the operator is not the only one interested in his cost figures, but that his executive is also so interested, when the accountant, who is independent of the operator, vouches for the figures shown, they will certainly have more weight than if the operator makes them up in his own way, and if they are diversant from the financial or accountant's books.

The degree of finesse to which any cost system can be installed is determined by the wishes of the superintendent, but it should be also determined by experience. Expense is also often a consideration.

If (as doubtless it will be, where applicable) the unit cost system is desired, it could be and has been as readily installed in stamp milling as it has been used elsewhere, in flour mills, cotton mills, steel mills, railroads and public utilities, etc., by accountants.

To say that the accountant is not interested in the unit cost, is to exaggerate slightly. It is his duty to be interested in that, and in any other thing in the line of accounts that any individual requires. And further, as the unit cost is determined by the "dollar and cents" costs, he will undobutedly have an endless chain of interest as long as costing is the subject.

An example of how the accountant is interested in the operating figures and the financial figures at the same time is this: Assume a milling company purchasing various parts of machinery, to be installed, worth say $1000. The operator having no books is compelled to write it all off in his cost sheet in the first month, instead of being able to open a "suspense account" and proportion this charge reasonably over the proper life of the machinery. Inasmuch as this will affect the profit and loss account of the company in the month it is written off, and also in the subsequent month it should have been written off, it is interesting to the financial end, more especially as the possibility is that with a large concern, the $1000 item mentioned above will be manifoldly increased.

In fact in many more ways than this the operator (if unattached to the financial department of the concern) can be responsible for unreliable statements of the company, as well as cost sheets that would deceive himself.

I think the particular reason that poor results are often obtained, is the fact that many engineers are too prone to belittle the intelligence of the accounting department, and to consider this department as "only a necessary expense to be kept as low as possible," and that they therefore are too ready to employ cheap material instead of obtaining men with experience, training and intelligence in cost accounting. Mayhap Mr. Haynes has been in environments of this character, and it is to be regretted that this state of affairs exists.

It should be the keynote of both the engineering and accounting professions in regard to cost keeping, to submerge their own and their departmental antagonisms, and co-operate in a friendly business way to both design and carry out costing to the beneficial health of the whole corporation of which they are units.

The operator may feel that "errors are creeping into the very foundation" of his data, and "that exact distribution is unobtainable." This can certainly be remedied by his getting together with the accounting department and co-operating with them to put in the proper forms and system that will give him absolutely reliable information.

The cuts that Mr. Haynes has displayed are interesting as examples of what are especially adapted to his requirements, but are only synonymous with like information obtained from systems installed universally by accountants.

In conclusion, I would say, that the field of cost accounting is so broad and varied that it behooves all of us to broaden our viewpoint and knowledge for the betterment of all concerned, and it is treason to intelligence to infer that a chemist (for example) can have knowledge of chemistry and nothing else, or an engineer of engineering and nought else, etc., etc., or that nobody else can be of use to him even in his own sphere. He should rather be prepared to interest others in his work. Only with a viewpoint of unity can it be possible for the executive-in-charge to arrive at the best reliable information regarding the cost accounting placed before him—that is by the joining of the ideas of the accounting and engineering staff, and the relating of the costs to the financial records.

ERNEST G. ASHBY.
Accountant, Cyanide Plant.
Alaska Treadwell Gold Mining Co.,
Treadwell, Alaska.

## Toronto Meeting of American Chemical Society Postponed

The meeting of the American Chemical Society which was to be held in Montreal, Canada, in September, has been indefinitely postponed on account of Canada being involved in the European war, and it now seems improbable that any meeting of the Society will be held this fall for the reading of papers. The present outlook is that the next meeting of the American Chemical Society will be in New Orleans, April 1 to 3, 1915.

The **American Foundrymen's Association** and the **American Institute of Metals** will hold the annual meeting in Chicago from September 7 to 11. The program of the American Institute of Metals comprises joint meetings with the American Foundrymen's Association on Tuesday and Wednesday, 10 a. m., and separate meetings on Tuesday, 2 p. m., Thursday, 10 a. m. and 2 p. m., and Friday, 10 a. m. On Monday evening the Foremen hold a banquet at the La Salle Hotel, and on Thursday evening the American Institute of Metals holds a meeting at the same place.

# The European War and the Chemical Industries of This Country

The European war is affecting the chemical industries of this country in the most varying phases. To get a clear view of the situation, Metallurgical and Chemical Engineering has interviewed a few men, prominent in American chemistry. To serve as a general guide the following questions were asked:

1. How does the cutting-off of the supply of certain raw materials by the European war affect the continuity of operation of the various chemical industries in this country? Can any of these raw materials be procured in the United States so as to make our industries independent of other countries? What is the situation of the potash industry?
2. Will the forced industrial restriction in Europe, if it continues long enough, warrant the development in this country of chemical industries which have so far been almost exclusively European? What are the possibilities of an American coal tar industry?
3. In the case of a long continued war, do you think that the personnel of the American chemical and metallurgical industries will be affected? Do you think it possible that there may be a scarcity of chemically trained men or of unskilled workmen?
4. Is there enough demand in South American countries for products of the chemical industries to make exports from this country worth while and open new markets for the chemical industries of this country?

* * *

## Interview with Dr. Wm. H. Nichols

CHAIRMAN OF THE BOARD, GENERAL CHEMICAL COMPANY; PRESIDENT, NICHOLS COPPER COMPANY; PAST PRESIDENT OF THE SOCIETY OF CHEMICAL INDUSTRY; AND PRESIDENT OF THE EIGHTH INTERNATIONAL CONGRESS OF APPLIED CHEMISTRY, 1912.

In an interview given to the Editor of Metallurgical and Chemical Engineering on August 21, Dr. Wm. H. Nichols stated that at the present moment no one is in position to arrive at definite conclusions concerning the effect on this country of the European war, as conditions are rapidly changing day by day, and past events have given us very little on which to base present conclusions. He emphasized the fact, however, that we had certainly learned that it was unnecessary for the American business man to worry; that patience and calmness would be amply repaid in the better frame of mind in which the Americans would approach the thousands of new problems which are constantly arising, and which will, of course, have to be solved.

The European war will put the American chemist on his mettle, and he will certainly arise to the emergency and demonstrate that he is made of the right stuff.

In reply to the four specific questions given above, Dr. Nichols stated as follows:

1. The supply of raw materials, as far as the field of heavy chemicals is concerned, would appear to call for no alarm and comparatively little uneasiness. Pyrites, nitrate of soda, and material of that kind, though coming largely from Spain, South America and other foreign ports, seem to be arriving with considerable regularity, and should not seriously jeopardize those chemicals used in the manufacturing of the first chemical raw material. Stassfurt potash supply, upon which the world depends, is, of course, entirely cut off. The American farmer may have to get along for the time being without potash fertilizers; but other substitutes will take their place for the present. Potash for other industries used in smaller quantities may be secured from sea weed or feldspar. Necessities will develop other sources of supply than the German mines. With the chemicals that this country has depended upon Germany supplying, covering a wide range from certain salts, such as epsom salts made from kieserite, which industry Germany has entirely stifled in this country, through to finished dyes, which have never been made in quantity outside of the large German factories, it is too early to state what America will do; but it is safe to say that most of them we can get along without when necessity dictates.

2. The prospect of the American coal tar industry will depend very largely on the encouragement which the American buyer will give to the American manufacturer. The experience of the Benzol Products Co., which started in a small way to manufacture aniline oil in this country, illustrates the attitude that Europeans have always taken where Americans have tried to parallel their manufacturing experiences. They decided that the American plant must be killed off, and although a tariff of 10 per cent was placed on aniline oil by the Democratic Congress, foreign manufacturers reduced the price to a point where it was impossible to compete. It has heretofore been found impossible to secure encouragement for certain lines of manufacture here from the buyer of chemicals, and it is largely through the desire of the American purchaser to secure his goods at the lowest possible price that the color industry has not been able to get a foothold. The development of this branch of the chemical industry is, therefore, entirely in the hands of the buyers, and no manufacturer can predict what is likely to come out of the present curtailment of imports of necessary chemicals to this country.

3. A scarcity of trained chemists or unskilled workmen seems to be at the present time entirely out of the question, although it is, of course, hard to foresee what technical knowledge will now be called into use.

4. The South American market for chemicals is an important one, and though it is not yet developed, it may be expected to grow into an important outlet for American products. The difficulties of doing business in South America has largely been caused by lack of proper banking facilities, and it is only after this problem is solved that we may turn to the Southern republics as large consumers of our products.

With regard to the copper market, he stated that the situation was quite remarkable, and that the producers had for the first time in their history been unanimous in showing a large amount of common sense. All copper mines had reduced production by 50 per cent or even more and the refineries had, of course, followed suit, the Nichols Copper Company plant being run at present at about 50 per cent of its capacity. As, approximately, one-half of the copper produced has heretofore gone abroad, this curtailment should make it possible to provide for all of the local requirements, so that when the war is over the metal should be in a good and strong position.

He again emphasized that in this crisis the American copper men have shown more sense than ever before, and that they had been absolutely unanimous.

In summing up, Dr. Nichols took a very reassuring view of the whole situation. He admitted that it would be necessary to readjust ourselves to new conditions, but that in his opinion American ingenuity will solve most, if not all, of the problems as they arise.

He gave as an example of American resources—the sugar situation. As the price goes up, glucose or corn syrup will take its place in many fields. Glucose cannot, of course, replace granulated sugar, but it most certainly will add a cheap substitute for sugar in many household uses.

The interruption of the shipment of jute to this country had also called for the ingenuity of the American manufacturers, who are in some places replacing rough cotton bags for the heretofore indispensable jute bags.

He considered that there would be no danger of lack of necessities of life, but that the extravagances of the last few years might have to be restrained.

It would appear from our interview that Dr. Nichols considers this a great opportunity for the American chemist to show what he is able to accomplish.

* * *

### Another Reassuring View of the General Situation

**Mr. Maximilian Toch** (partner of Toch Brothers) remarks that since the war was declared his firm has been working night and day, and he is of the opinion that this is the finest opportunity that America has ever had for the development of her chemical industries.

1. The cutting off of supply of certain raw materials will, of course, cripple the chemical industries for the time being. There is no doubt that matters will right themselves, because we are more or less of a pioneer nation, and a pioneer can always help himself. In the case of raw materials, it would be difficult to say exactly how many of the raw materials can be procured in the United States which were formerly imported. Of course, indigenous raw materials cannot be made excepting in the country where they are grown or procured, such as the fossil resins. Still, we are able with the aid of China wood oil and resin to do many things we could not do 10 years ago, but China wood oil, in case our supply is cut off, could be produced in time in America, for the Department of Agriculture, through the able work of David Fairchild, has planted a number of Kiri nut trees.

As regards the potash situation there are a number of methods for the extraction of sufficient potash from felspar, kelp and the like. Many of the methods, some of which are patented, have never been exploited on account of their cost, but for the present cost will not enter, and therefore we should have no fear that the supply of potash will be curtailed if we can make a sufficient quantity from many of the potash-bearing materials in the United States.

2. The forced industrial restrictions in Europe, whether they continue long enough or not, by all means warrant the development in this country of many of the chemical industries which we have slighted in times gone by. With the exception of the patented coal tar colors, Mr. Toch sees no reason why all the others should not be made here, and as near as he can glean, two concerns are already starting in to erect installations for the purpose of making many of the coal tar colors which have heretofore only been made in this country on a small scale.

3. "I do not consider that there will be a scarcity of chemically trained men or skilled workmen in the case of a long continued war. Opportunity always brings out the best that there is in us, and in my own case I have advanced some men owing to sudden increased business and feel that they will fill the positions capably.

4. "There is a sufficient demand in South American countries for the products of the chemical industries to make exports from this country worth while. In the paint, varnish and chemical industry very few materials have ever been exported to South America. It is just three weeks ago since hostilities became general, but within the last three weeks our firm has received two substantial orders from South America from a district where English and German competition has prevented us from selling."

* * *

### Interviews on the Coal-Tar Industry

**Mr. William J. Matheson** (president Matheson Lead Company, vice-president Corn Products Refining Company, director American Cotton Oil Company, Benzol Products Company, Cassella Color Company, General Chemical Company) comments on question (2) as follows: "In regard to the organic chemical industries, especially the primal products, such as aniline oil, aniline salts, beta naphthol, paranitro aniline, etc., the industry is already developed, and its growth depends in large measure upon the supply of cheap benzol. These products are made by the Benzol Products Company.

"As to coal-tar colors or dyes, I would not attempt to add to the able paper[*] that has been presented on this subject by Dr. Hesse."

* * *

**Dr. B. C. Hesse** (chemical engineer and expert, 90 William Street, New York City) comments on question (2), with special reference to the coal-tar industry, as follows:

In the coal-tar industry the following three divisions may be made for convenience and clarity:

I. Products from coal-tar by distillation, expression and like operations.

II. Products obtained from I by chemical transformation but not themselves dyes.

III. Dyes made from II.

I and II make up practically all of paragraph 536 of the United States Tariff of 1909.

According to what purport to be official German figures Germany's foreign trade in 1913 in these three classes was as follows (in metric tons):

| | Imports into Germany | Exports from Germany | Excess of Exports over imports |
|---|---|---|---|
| I ........ | 67,501 | 342,893 | 275,392 |
| II ........ | 673 | 16,311 | 15,638 |
| III........ | 3,238 | 163,874 | 160,636 |

Obviously division I need not be further considered. As to division II the German figures are given in three subdivisions:

(a) Anilin oil and salt.

(b) Naphthol and naphthylamin.

(c) Anthraquinone, nitro-benzol, toluidin, resorcin, phthalic acid and other coal-tar products.

For division III the German figures are given in four subdivisions:

(d) Aniline dyes.

(e) Anthracene dyes, other than Alizarin red.

(f) Alizarin red.

(g) Indigo.

At present the United States produces about 30 per cent of its requirements of aniline dyes (division III), but almost entirely from materials of division II brought from Germany.

The key to the situation lies in division II and in this Germany controls the world's markets. This control is due to the facts that while the growth of this division was relatively slow, yet the field has become very much interwoven, each of its hundred or more products are dependent upon or made up of one or more other products, no one of them is of use without still others; the industrial and commercial conditions or relations have grown with the technical development so that the coal-tar dye industry is really a conglomerate of many separate parts acting and reacting upon each other, commercially and industrially.

---

[*] This paper is printed on p. 581. See also the following interview.—Editor.

Not a single one of the 22 factories in Germany is wholly independent of other factories in Germany, whereas together they are independent of sources outside of Germany, or can very readily be so should occasion arise. It would not do merely to transplant even the largest German works to this country; a part of probably each German works would be necessary to produce here or anywhere a complete and self-contained industry. Such a transplanting of the coal-tar dye industry would be comparable to an attempt to transplant to this country *every single branch* of, say, the textile industry or any other highly ramified and diversified art.

Germany's supremacy in this field has been for more than 30 years a standing challenge not only to the chemists and capitalists of the United States but to the chemists and capitalists of all the rest of the world as well. Except Switzerland, no country has succeeded in selling Germany more coal-tar dyes than it buys from Germany, but all of them *without exception* buy more of intermediate products, i. e., division II, from Germany than they sell Germany.

The seven European countries other than Germany noted for their chemists and having a large and flourishing chemical industry are Austria, Belgium, France, Great Britain, Italy, Russia and Switzerland. Their indebtedness in metric tons to Germany, together with that of the United States, for 1913, the countries being arranged in the order of their total indebtedness which is distributed over the seven items, follows:

| | Division II | | | Division III | | | | |
|---|---|---|---|---|---|---|---|---|
| | a | b | c | d | e | f | g | |
| | Anilin Oil | Naphthol and Naphthylamin | Anthra Quinone, etc. | Anilin Dyes | Varicolored Alizarins | Alizarin Red | Indigo | Net Totals |
| 1. United States | 2,428 | 638 | 965 | 13,855 | 2,164 | 493 | 3,461 | 24,004 |
| 2. Great Britain | 340 | 333 | **34 | 10,793 | 1,130 | 1,493 | 1,180 | 15,235 |
| 3. Austria | 655 | 109 | 284 | 5,582 | **223 | 207 | 1,361 | 7,975 |
| 4. Italy | 650 | .... | 825 | 4,097 | 158 | .... | 662 | 6,392 |
| 5. Russia | 602 | 1,117 | 998 | 1,098 | 156 | 174 | 434 | 4,579 |
| 6. Belgium | 120 | .... | 108 | 2,400 | 96 | .... | 313 | 3,037 |
| 7. France | .... | 217 | 776 | 1,301 | 124 | 98 | 323 | 2,839 |
| 8. Switzerland | 1,217 | 272 | 1,201 | **941 | .... | 259 | .... | 2,008 |
| Net totals | 6,012 | 2,686 | 5,123 | 38,185 | 3,605 | 2,724 | 7,734 | 66,069 |
| Number of countries Germany exported to | 11 | 6 | 11 | 32 | 12 | 9 | 21 | |

Summarized by divisions II and III the results are:

| | II | III |
|---|---|---|
| United States | 4,031 | 19,973 |
| Great Britain | 639 | 14,596 |
| Austria | 1,048 | 6,927 |
| Italy | 1,475 | 4,917 |
| Russia | 2,717 | 1,862 |
| Belgium | 228 | 2,809 |
| France | 993 | 1,846 |
| Switzerland | 2,690 | ** 682 |

**Credit

According to the latest information available the number of coal-tar dyestuff works in the world and their geographical distribution in 11 countries is as follows, in the order of their number of factories: 22 Germany, 11 France, 11 Great Britain, 9 United States, 4 Austria-Hungary, 4 Switzerland, 2 Holland, 2 Russia, 1 Belgium, 1 Greece, 1 Italy.

In the course of the development of this business 16 plants that made coal-tar dyes have abandoned that work, 11 in Germany and one each in Austria, Belgium, France, Great Britain and Switzerland. Fourtenn have been absorbed by others, six in Germany, four in Switzerland, two in France and one each in Belgium and Holland.

Where these seven countries together have failed so signally it cannot be fairly urged as a fault of the chemists of this country that they have not succeeded.

There is another side to this, namely, the investor's side. A self-contained and complete coal-tar dye industry in this country would to-day call for preparedness to make about 700 different dyes. In the fiscal year 1913-1914 this country imported indigo to the extent of $1,093,226, alizarin to the extent of $815,459, both of which are without tariff protection; $7,464,134 worth of aniline dyes with a duty of 30 per cent and aniline oil with a duty of 10 per cent. This means 700 different aniline dyes would average a gross annual income each of about $10,000. To introduce 700 different sets of operations and perhaps half that many different sets of apparatus at *one time* to produce on the average for each set of operations a gross of $35 per day can hardly be regarded as an attractive proposition when the initial lump gross outlay would be not less than $5,000,000 actual cash. Each of these 700 products requires good manufacture from the start because good qualities of each are already on the market. It is one thing to grow and develop such an industry or art and to maintain it against newcomers, but it is quite a different thing to build it up afresh and in its entirety in the face of competition and to hold it against those who developed the business, know all its ins and outs, have their experience and plant bought, paid for and written off long ago. It could hardly be expected that if successful this would employ as many as 7000 people all told and the gross makes out less than 0.4 per cent of our total import business.

With unlimited and immediately available capital the American chemist can build up such a complete industry, but the dividends would be a long way off. Capitalists, American or otherwise, do not take kindly to such handicaps or obstacles, and justly so.

The truth seems to be that the whole of this industry cannot be successfully transplanted and attempts to transplant part only have not resulted in any self-contained and independent industry anywhere but in a thing whose real roots are still in German soil and if it could be transplanted as a whole the net result would not be commensurate with the expense, effort and risk connected with it. What portion or part if any, and the equivalent of a complete and self-contained industry for all the domestic needs of this country could ultimately be transplanted here is a problem that has had the serious attention of competent chemists and capitalists in this country for many years without a definite or satisfactory answer thereto having been arrived at. If the present conditions will contribute to a solution thereof cannot be decided out of hand, the first impression certainly is that they will *not* so contribute.

Dr. Louis J. Matos (of the technical staff of the Cassella Color Company) points out that the question is: *Can* aniline dyes be made here in the present emergency, and in sufficient quantity and variety for our mills?

The question is not, primarily, whether we have the necessary complement of those "highly specialized and trained chemists" always connected with the dyestuff industry in discourses, but whether we produce a sufficient quantity of coal tar to make us independent of any foreign source of tar, and also whether higher prices cannot be obtained for certain tar distillates and fractions from commercial outlets other than the color industry could afford to pay.

Immense quantities of naphthalene are consumed here in the form of "tar camphor," and it is probable that much of this is available from tars produced here, and which could conveniently serve as a most valuable raw material or starting product for a most extensive series of dyes of which it is the base.

Lower fractions of the tar distillates, including *toluol*, are undoubtedly produced here, and in this case we have another initial raw material for a wide range of dyes.

Patent matters in connection with the dyes are of great importance, and for the extension of the tar color industry here the expired patents of still useful dyes would be made first.

To my mind it is not so much a question of inability of our chemists to produce dyes; for I believe that those trained in *practical* organic chemistry (not necessarily research chemists) would in a short time grasp the situation quickly, but it is a question of the *temporary handicap of not having the especially designed and constructed appliances* that are necessary for the proper conduct of the technical operations in elaborating the several raw materials to middle and ultimate products.

Here is the familiar example of benzopurpurine 4 B, one of the most common cotton dyes; starting with *toluol* and gradually converting this into *tolidine* means four chief processes made up of a succession of minor operations, thus: Toluene is nitrated, kept cool, and then distilled, the resulting nitrotoluene is reduced with zinc and caustic soda, yielding hydrazotoluene which is in turn broken up with muriatic acid, giving us the tolidine, which we combine with naphthionic acid, which is also the end product commencing with naphthalene, and converted in turn into nitronaphthalene, then naphthylamine, and finally naphthionic acid.

In the foregoing, no mention is made of the appliances that must be installed for the particular purpose of working the chemical reactions.

The problem is to provide for the chemical engineers' side of the factory work, and with a proper conservation of our own tars, it is not impossible that a wide range of colors might be produced here.

To found an industry is, however, quite a different matter from starting a factory, and for an industry to proceed orderly, requires that there must be at hand raw material and the constructive engineering ability to take care of the elaboration, and in this particular industry our American machinists and constructors have not been called upon to show what they can do.

## The Iron and Steel Market

All the iron and steel producing countries of any consequence, with the sole exception of the United States, are engaged in the fiercest and most destructive war of all time. The countries at war are those that have been engaged in financing the development of non-productive but consuming countries, these countries having of late been taking from the producing countries upwards of 10,000,000 tons of finished steel a year, besides large quantities of machinery, hardware and cutlery, involving perhaps a couple million tons in addition. Of the total tonnage the United States has been furnishing about one-fourth.

A condition is presented the effects of which are impossible to gauge. There is no experience to guide, and the situation is so new that thus far it presents no trends that can be studied to advantage.

To add to the complexity, the iron producing countries at war are differently affected. Germany is hemmed in and cannot pursue her foreign commerce. England seems able shortly to resume her commerce, so far as ocean transport is concerned, but may be crippled in actual production through shortage of men, and perhaps also of certain raw materials.

The desire for commerce was at the root of this war, and it is natural and consistent that England should now endeavor to continue and even, if possible, expand her commerce. The United States is equally disposed to expand its commerce, but instead of being able at once to begin expanding, is confronted at the outset with a lack of ocean transportation facilities to continue the commerce already acquired, and is faced with the prospect that the so-called "neutral markets," through the withdrawal of European financial accommodations and a complete tying up of the mediums of international money exchange, are unable at the moment to buy.

At the first announcement of war the steel trade of the United States appeared to embrace the conclusion that an immediate and large demand would spring up for its products, but it required only a few days of observation and consideration to develop that the most serious difficulties lay in the way.

A problem serious in itself arose from the shutting off of imports of ferromanganese, manganese ore and Austrian magnesite. Ferromanganese, which had been readily available at $37 for German and $38 for English, f. o. b. Baltimore, jumped to $140 or $150 for odd lots to be shipped from surplus stocks, though a decline has since occurred to a trifle above $100, there being promise of an early resumption of shipments from England, though possibly on a restricted scale. Eventually there may be larger imports than formerly of manganese ore from Brazil and India. For magnesite a substitute, however expensive in the use, will doubtless have to be found.

The domestic trade of the United States has been affected in various ways. There has been some tendency on the part of buyers to take early deliveries from mills, on contracts made at recent minimum prices, through fear of a possible shortage later, while on the other hand there has developed a strong feeling of conservatism as to fresh purchases. New projects that require financing have been indefinitely held up.

What has occurred thus far since the war started is probably no index of what may follow. Early in August prices of bars, plates, shapes and sheets were advanced, largely as a precautionary measure on the part of the mills, faced by higher prices for ferromanganese and the possibility of a labor shortage, and additional advances are predicted. The wire advance of August 21 did not grow out of the war, but was a sequel to the advance of July 20, advances in wire products, on account of the peculiar manner in which the wire market is conducted, usually being made in multiple. Steel prices in general may advance further as the war progresses, but there is no clear indication thus far that such will be the case.

As to domestic demand, the total has not thus far been materially reduced, but as work in progress is completed there may be a decided slackening.

As to exports, the first war effect was to shut off the movement entirely, through there being no ocean movement and no means for payment. The first step is to restore exports to the former volume, the second being, if possible, to increase the volume, and that second step may not be reached for months. That the building up of an export trade will be slow is suggested by the fact that our exports to Canada have been decreased, instead of being increased by the fact that British exports to Canada were immediately, though presumably only temporarily, shut off. Indeed, the Canadian steel manufacturers themselves have decreased their production.

As to domestic trade, it is significant that while some fairly large railroad buying was expected to follow a decision in the eastern rate case, rendered August 1, the fact is that orders for only 2,000 freight cars were reported during August, when the monthly average during the first seven months of the year was about 10,000 cars.

The steel mills operated during August at about 65 per cent of capacity, or at about the same rate as in July, when the prospects had been that operations would steadily increase. At the moment the prospect is that September output will be less rather than more than the August output.

### Pig Iron

The pig iron market has been practically stagnant during August, and the seaboard markets, relieved of the fear of imports, have been unable to stiffen. Deliveries have shown practically no change, but it is uncertain whether they can be maintained indefinitely. Prices are largely nominal, and are quotable at little variation from those of a month ago: No. 2 foundry, f. o. b. Birmingham, $10 to $10.25; delivered Philadelphia, $14.25 to $14.50; f. o. b. furnace, Buffalo, $13 to $13.50; f. o. b. furnace, Chicago, $14; f. o. b. valley furnaces (90 cents higher delivered Pittsburgh) Bessemer, $14; basic, $13; No. 2 foundry and malleable, $13 to $13.25; gray forge, $12.50 to $12.75.

### Steel

The mills have marked up quotations about $1 a ton since the war, the advance being based partly upon higher prospective costs, and it is asserted in some quarters that further advances will soon be made. Consumers are fairly well covered by old contracts. The market is quotable at $20.50 and $21.50 for billets and sheet bars respectively, f. o. b. maker's mill, Pittsburgh, and at $20 and $21 respectively at maker's mill, Youngstown, rods being about $26, Pittsburgh.

### Finished Steel

Finished steel prices are firmly maintained, in most cases at advances from quotations of a month ago. Prices quoted below are for prompt shipment, fourth quarter shipment being as a rule $1 or $2 a ton higher. Quotations are f. o. b. Pittsburgh, unless otherwise stated, with full freight to point of delivery, and the Chicago and eastern markets are practically on this basis, concessions of part of the freight having practically disappeared.

Rails, standard sections, 1.25c. for Bessemer, 1.34c. for open-hearth, f. o. b. mill, except Colorado.

Plates, tank quality, 1.20c.

Shapes, 1.20c.

Steel bars and bands, 1.20c., base.

Iron bars, 1.25c., Pittsburgh; 1.17½ to 1.22½c., Philadelphia; 1.07½ to 1.10c., Chicago.

Sheets, blue annealed, 10 gage, 1.40c.; black, 28 gage, 1.90c.; galvanized, 28 gage, 2.90c.; painted corrugated, 28 gage, 2.10c.; galvanized corrugated, 28 gage, 2.95c.

Steel pipe, ¾ in. to 3 in., 80 per cent. off list.

Steel boiler tubes, 3½ to 4½ in., 72 per cent. off list.

Wire nails, $1.60, base; smooth fence wire, 1.40c.; galvanized fence wire, 1.80c.; galvanized barb wire, 2.00c.

Standard railroad spikes, 1.45 to 1.50c., Pittsburgh; 1.50 to 1.55c., Chicago.

Structural rivets, 1.55 to 1.60c.; boiler rivets, 1.65 to 1.70c.

Cold rolled shafting, 66 per cent. off list.

Chain, ⅜ in. proof coil, 3.05 to 3.15c.

---

**The American Boiler Manufacturers' Association** will hold its 26th annual convention in New York City from September 1 to 4, with headquarters at the Waldorf-Astoria Hotel. Mr. F. B. Slocum, West and Calyer Streets, Brooklyn, N. Y., is the secretary.

**The Hardinge Conical Mill Co.**, of New York City, has received a fifth repeat order from the Braden Copper Company of Rancagua, Chile, for six Hardinge mills. These mills are all 8-ft. diameter by 48-in. cyl. and are to be driven by single-reduction herringbone gears of the Wuest type.

## The Western Metallurgical Field

### The Complex-Ore Problem

In the editorial summary of the symposium on complex ores, published in our July issue, an important point suggested by one or two of the contributors was not sufficiently emphasized. The economic loss of metals, particularly lead and zinc, due to imperfect methods of separation by ore-dressing methods is an item which, in the aggregate, must be tremendous. The smelter demands concentrates of a certain grade and purity in order that he may conduct his own operations to the best advantage. This places a limitation on the ore producer who, in meeting the demand for marketable concentrates, usually finds it necessary to sacrifice high recovery. Metallurgical saving is subordinated to economic recovery, and losses accrue proportionately. Lead remaining in zinc concentrate represents an economic loss, and the same is true of zinc in lead concentrate.

An illustration of these losses was given, referring to a published statement of a Montana producer of zinc concentrate. The recovery was high—90%—and the grade of concentrate was good—50% zinc; but it contained also small percentages of lead and copper, with some silver and gold. The gross value of the merchantable metals, based on current quotations, was about $80 per ton of concentrate. The actual market value at the smelter was about $24, leaving a difference of $56. A part of this difference is accounted for in freight, smelting and marketing charges, but much of it probably represents a loss to the producer due to economic conditions in the smelting industry. Such instances emphasize the limitations of present methods of concentration and increase the demand for new processes that are more efficient.

### Dry Jigging Unsized Ore

One of the features of the Plumb pneumatic jig, described in this journal December, 1913, page 722, is its ability to produce concentrates of unusually high grade. In fact, according to the principle on which the jig operates, only high-grade, clean concentrates can be produced, and the saving is proportional to the degree in which the minerals have been unlocked in crushing. Some of the tests made by jigging the concentrates from wet tables showed the possibility of improving the grade to such an extent that their commercial value was greatly enhanced. In general, one of the advantages of the machine is that it overcomes in a large degree the economic loss referred to above in the concentration of lead-zinc ores, because the concentrates are not only of high grade, but the percentage recovery also is high.

At the time the jig was first described it was considered necessary to provide a feed that was sized within reasonably wide limits, say —12+20, —20+40 and —40+150 mesh. Ore finer than 150-mesh was not treated, as that size was considered outside the field of the machine. A recent development is that unsized feed can be treated as efficiently as sized feed, without eliminating the finest portion. This offers an advantage in avoiding the cost and trouble of sizing, as well as saving the mineral formerly discarded in the —150 mesh portion and treated on wet slime concentrators.

The development will sound illogical to those who have followed dry concentration, because sizing has been considered one of the prerequisites for successful work. But it is quite as logical as Joplin practice of wet-jigging unsized feed, where the fine mineral finds its way through the bed into the hutch, and the coarser grades accumulate on the bed and are discharged. It has been found that the same conditions obtain in a

Plumb pneumatic jig, working with a coarser screen than was formerly used. After a suitable bed has been formed coarse and fine mineral are recovered, the former at the usual discharge weir and the latter through the hutch. Apparently this is one of the cases where sizing can be dispensed with.

### Telluride's Disaster

Engineers throughout the country will regret to learn of the disaster which befell the mining community of Telluride on July 27, as the result of a cloudburst in the Sawtooth range, north of the town. The flood of water and mud which poured out of Cornet Creek canon, followed closely after a heavy rain, and covered about fifteen blocks in the central business and residential section with mud and debris to a depth of from four to ten feet. Detailed reports of the disaster tell of residences swept away by the flood, and others filled with mud and boulders. The New Sheridan Hotel, which has been the rendezvous of engineers visiting Telluride, was one of the business blocks inundated. The Commercial Club was wrecked and filled with mud to within a few inches of the ceiling. The First National Bank building also was damaged.

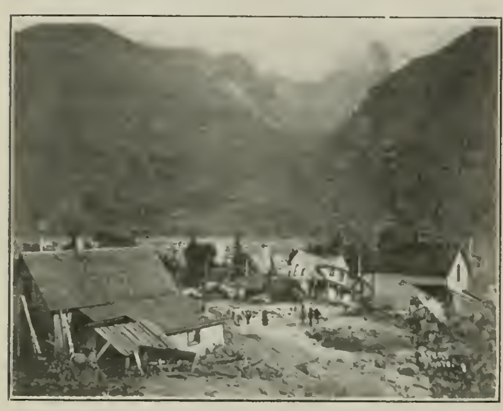


FIG. 1—PATH OF FLOOD FROM MOUTH OF CANON, LOOKING TOWARD BEAR CREEK

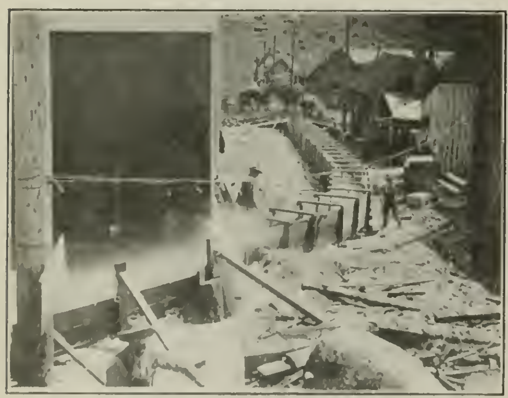


FIG. 2—SLUICE CONSTRUCTION

Immediately following the storm, a committee headed by Mr. Charles A. Chase, manager for the Liberty Bell Gold Mining Co., laid plans for cleaning the town. A flume was constructed through the inundated section, and by the aid of the water from Cornet Creek and the local water system the accumulation of mud was sluiced to the San Miguel River. It will be several weeks before the tremendous volume of mud and debris can be removed.

The flood occurred about one o'clock in the afternoon, which possibly accounts for the fact that but one fatality resulted. The loss is estimated at about $200,000, sustained by residents and business houses. The local mining companies contributed liberally to a relief fund, but it is likely that offers of financial assistance from other sources outside Telluride will have to be accepted.

### Purchase of Aurora Consolidated

The Goldfield Consolidated Mines Co. has issued an official statement regarding the terms of its purchase of the property of the Aurora Consolidated Mines Co., at Aurora, Mineral county, Nevada. The Goldfield company purchased 592,000 shares, equal to 87% of the issued shares of Aurora Consolidated, at a price of $1.28887 per share, or on the basis of $877,075 for the entire issue. Cash paid on June 25, the date of purchase, was $388,800; three subsequent payments of $100,000 each, with interest at 6% per annum were arranged for at thirty-day intervals, and the final payment of $74,211 is tot be made on October 25. At the time of the purchase, mining and milling equipment with an estimated capacity of 500 tons per day was practically completed and ready for operation. The estimated net value of fully and partly developed ore, after deducting estimated cost of realization, was $893,000. The developed ore has a gross value of $4.81 per ton, from which it is expected to realize a net profit of $1.50 per ton by cyanidation. Owing to the disbursement of a large sum in this purchase, the Goldfield company has omitted its usual dividend payment.

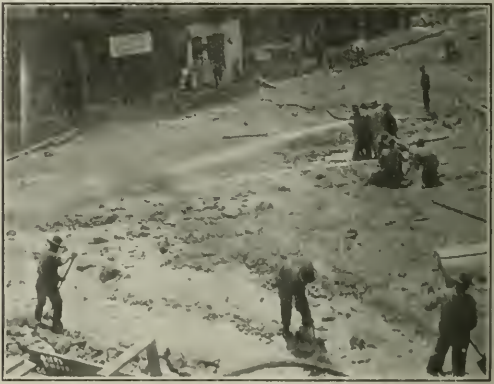


FIG. 3—SLUICING—THE SIDE OF SLUICE REMOVED AND MUD FORCED IN BY FIRE HOSE

### Calumet & Hecla to Leach Tailings

Although no details are available at the present time, it is understood that the Calumet & Hecla Mining Co., Michigan, is planning to leach the tailings from its new regrinding and reconcentrating plant. Tailings from early concentration are to be dredged from Lake Linden, reground in Hardinge mills and reconcentrated. The tailings will then be classified in Dorr classifiers of special design, and the sand product subjected to a leaching process to recover the contained copper.

## Some Aspects of Industrial Chemistry*

BY DR. L. H. BAEKELAND

While I appreciate deeply the distinction of speaking before you on the occasion of the fiftieth anniversary of the Columbia School of Mines, I realize, at the same time, that nobody here present could do better justice to the subject which has been chosen for this lecture than the beloved master in whose honor the Charles Frederick Chandler Lectureship has been created.

Dr. Chandler, in his long and eminently useful career as a professor and as a public servant, has assisted at the very beginning of some of the most interesting chapters of applied chemistry, here and abroad.

Some of his pupils have become leaders in chemical industry; others have found in his teachings the very conception of new chemical processes which made their names known throughout the whole world.

Industrial chemistry has been defined as "the chemistry of dollars and cents."

This rather cynical definition, in its narrower interpretation, seems to ignore entirely the far-reaching economic and civilizing influences which have been brought to life through the applications of science; it fails to do justice to the fact that the whole fabric of modern civilization becomes each day more and ever more interwoven with the endless ramifications of applied chemistry.

### Beginning of Chemical Industries in France

The earlier effects of this influence do not date back much beyond one hundred and odd years. They became distinctly evident during the first French Republic, increased under Napoleon, gradually spread to neighboring countries, and then reaching out farther, their influence is now obvious throughout the whole world.

France, during the revolution, scattered to the winds old traditions and conventionalities, in culture as well as in politics. Until then, she had mainly impressed the world by the barbaric, wasteful splendor of her opulent kings, at whose courts the devotees of science received scant attention in comparison to the more ornamental artists and belles-lettrists, who were petted and rewarded alongside of the all-important men of the sword.

In fact, as far as the culture of science was concerned, the Netherlands, Germany and Italy, and more particularly England, were head and shoulders above the France of "le Roi Soleil."

The struggles of the new régime put France in the awkward position of the legendary beaver which "had to climb a tree."

If for no other reason, she needed scientists to help her in her wars against the rulers of other European nations. She needed them just as much for repairing her crippled finances and her badly disturbed industries which were dependent upon natural products imported until then, but of which the supply had suddenly been cut off by the so-called Continental Blockade. Money-prizes and other inducements had been offered for stimulating the development of chemical processes, and —what is more significant—patent laws were promulgated so as to foster invention.

Nicolas Leblanc's method for the manufacture of soda to replace the imported alkalis, Berthollet's method for bleaching with chlorine, the beet-sugar industry, to replace cane sugar imported from the colonies, and several other processes, were proposed.

All these chemical processes found themselves soon lifted from the hands of the secretive alchemist or the timid pharmacist to the rank of real manufacturing methods. Industrial chemistry had begun its lusty career.

First successes stimulated new endeavors and small wonder is it that France, with these favorable conditions at hand, for a while at least, entered into the most glorious period of that part of her history which relates to the development of chemistry, and the arts dependent thereon.

It is difficult to imagine that, at that time, Germany, which now occupies such an enviable position in chemistry, was so far behind that even in 1822, when Liebig wanted to study chemistry at the best schools, he had to leave his own country, and turn to Gay-Lussac, Thénard and Dulong in Paris.

### Development of British Chemical Industry

But the British were not slow to avail themselves of the new opportunities in chemical manufacturing so clearly indicated by the first successes of the French. Their linen bleacheries in Scotland and England soon used an improved method for bleaching with chloride of lime, developed by Tennant, which brought along the manufacture of other chemicals relating thereto, like sulphuric acid and soda.

The chemical reactions involved in all these processes are relatively simple, and after they were once well understood it required mainly resourceful engineering and good commercial abilities to build up successfully the industries based thereon.

From this epoch on dates the beginning of the development of that important industry of heavy chemicals in which the British led the world for almost a century.

In the same way, England had become the leader in another important branch of chemical industry—the manufacture of coal-gas.

### Development of German Chemical Industries

The Germans were soon to make up for lost time. Those same German universities which, when Liebig was a young man, were so poorly equipped for the study of chemistry, were now enthusiastically at work on research along the newer developments of the physical sciences, and before long, the former pupils of France, in their turn, became teachers of the world.

Liebig had inaugurated for the chemical students working under him his system of research laboratories; however modest these laboratories may have been at that time, they carried bodily the study of chemistry from pedagogic boresomeness into a captivating cross-examination of nature.

And it seemed as if nature had been waiting impatiently to impart some of her secrets to the children of men, who for so many generations had tried to settle truth and knowledge by words and oratory and by brilliant displays of metaphysical controversies.

Indeed, at that time, a few kitchen tables, some clumsy glassware, a charcoal furnace or two, some pots and pans, and a modest balance were all that was needed to make nature give her answers.

These modest paraphernalia, eloquent by their very simplicity, brought forth rapidly succeeding discoveries. One of them was truly sensational: Liebig and Wöhler succeeded in accomplishing the direct synthesis of urea; thinking men began to realize the far-reaching import of this revolutionary discovery whereby a purely organic substance had been created in the laboratory by starting exclusively from inorganic materials. This result upset all respected doctrines that organic substances are of a special enigmatic constitution, altogether different from inorganic or mineral compounds, and that they only could be built up by the agency of the so-called "vital force"—whatever that might mean.

---

*An address given at Columbia University to inaugurate the Charles F. Chandler Lectureship. Copyrighted by the Columbia University Press, 1914.

Research in organic chemistry became more and more fascinating; all available organic substances were being investigated one after another by restless experimentalists.

Coal tar, heretofore, a troublesome by-product of gas manufacture, notwithstanding its uninviting, ill-smelling, black sticky appearance, did not escape the general inquisitive tendency; some of its constituents, like benzol or others, were isolated and studied.

Under the brilliant leadership of Kékulé, a successful attempt was made to correlate the rapidly increasing new experimental observations in organic chemistry into a new theory which would try to explain all the numerous facts; a theory which became the sign-post to the roads of further achievements.

### Stimulating Influences of the Dye Industry on Organic Chemistry

The discovery of quickly succeeding processes for making from coal-tar derivatives numerous artificial dyes, rivaling, if not surpassing, the most brilliant colors of nature, made the group of bold investigators still bolder. Research in organic chemistry began to find rapid rewards; entirely new and successful industries based on purely scientific data were springing up in England and France, as well as in Germany.

Some wide-awake leaders of these new enterprises, more particularly in Germany, soon learned that they were never hampered by too much knowledge, but that, on the contrary, they were almost continuously handicapped in their impatient onward march by insufficient knowledge, or by misleading conceptions, if not by incorrect published facts.

This is precisely where the study of organic chemistry received its greaetest stimulating influence and soon put Germany in this branch of science, ahead of all other nations.

Money and effort had to be spent freely for further research. The best scholars in chemistry were called into action. Some men, who were preparing themselves to become professors, were induced to take a leading part as directors in one or another of the new chemical enterprises. Others, who refused to forsake their teachers' career, were retained as advisers or guides, and, in several instances, the honor of being the discoverers of new processes, or a new dye, was made more substantial by financial rewards. The modest German university professor, who heretofore had lived within a rather narrow academic sphere, went through a process of evolution, where the rapidly growing chemical industry made him realize his latent powers and greater importance, and broadened his influence way beyond the confines of his lecture-room. Even if he were altruistic enough to remain indifferent to fame or money, he felt stimulated by the very thought that he was helping, in a direct manner, to build up the nation and the world through the immediate application of the principles of science.

### Industrial Research Laboratories

In the beginning, science did all the giving and chemical industry got most of the rewards; but soon the rôles began to change to the point where frequently they became entirely inverted. The universities did not furnish knowledge fast enough to keep pace with the requirements of the rapidly developing industries. Modern research laboratories were organized by some large chemical factories on a scale never conceived before, with a lavishness which made the best equipped university laboratory appear like a timid attempt. Germany, so long behind France and England, had become the recognized leader in organic manufacturing processes, and developed a new industrial chemistry based more on the thorough knowledge of organic chemistry than on engineering skill.

In this relation, it is worth while to point out that the early organic industrial chemistry, through which Germany was soon to become so important, at first counted its output not in tons, but in pounds—not in size nor in quantity, but in variety and quality.

Now let us see how Germany won her spurs in chemical engineering as well:

At the beginning, the manufacturing problems in organic chemistry involved few, if any, serious engineering difficulties, but required, most of all, a sound theoretical knowledge of the subject; this put a premium on the scientist, and could afford, for a while at least, to ignore the engineer. But when growing developments began to claim the help of good engineers, there was no difficulty whatsoever in supplying them, nor in making them cooperate with the scientists. In fact, since then, Germany has solved, just as successfully, some of the most extraordinary chemical engineering problems ever undertaken, although the development of such processes was entered upon at first from the purely scientific side.

In almost every case, it was only after the underlying scientific facts had been well established, that any attempt was made to develop them commercially.

### Methods of Healthy Development of Scientific Processes

Healthy commercial development of new scientific processes does not build its hope of success upon the cooperation of that class of "promoters" which are always eager to find any available pretext for making "quick money," and whose scientific ignorance contributes conveniently to their comfort by not interfering too much with their self-assurance and their voluble assertions. The history of most of the successful recent chemical processes abounds in examples where, even after the underlying principles were well established, long and costly preparatory team-work had to be undertaken; where foremost scientists, as well as engineers of great ability, had to combine their knowledge, their skill, their perseverence, with the support of large chemical companies, who, in their turn, could rely on the financial backing of strong banking concerns, well advised by tried expert specialists.

History does not record how many processes thus submitted to careful study were rejected because, on close examination, they were found to possess some hopeless shortcomings. In this way, numerous fruitless efforts and financial losses were averted, where less carefully accumulated knowledge might have induced less scrupulous promoters to secure money for plausible but ill-advised enterprises.

In the history of the manufacture of artificial dyes, no chapter gives a more striking instance of long, assiduous and expensive preliminary work of the highest order than the development of the industrial synthesis of indigo. Here was a substance of enormous consumption which, until then, had been obtained from the tropics as a natural product of agriculture.

Professor von Baeyer and his pupils, by long and marvelously clever laboratory work, had succeeded by-and-by in unraveling the chemical constitution of this indigo dye, and had finally indicated some possible methods of synthesis. Notwithstanding all this, it took the Badische Aniline & Soda Fabrik about twenty years of patient research work, carried out by a group of eminent chemists and engineers, before a satisfactory method was devised by which the artificial product could compete in price and in quality with natural indigo.

Germany, with her well-administered and easily enforcible patent laws, has added, through this very agency, a most vital inducement for pioneer work in chemical industries. Who otherwise would dare to take the risk of all the expenses connected with this class of creative work? Moreover, who would be induced to publish the result of his discoveries far and wide throughout the whole world in that steadily flowing stream of patent literature, which, much sooner than any text-books or periodicals, enables one worker to be benefited and to be inspired by the publication of the latest work of others?

### International Scope of Chemical Research

The development of some problems of industrial chemistry has enlisted the brilliant collaboration of men of so many different nationalities that the final success could not, with any measure of justice, be ascribed exclusively to one single race or nation; this is best illustrated by the invention of the different methods for the fixation of nitrogen from the air.

This extraordinary achievement, although scarcely a few years old, seems already an ordinary link in the chain of common, current events of our busy life; and yet, the facts connected with this recent conquest reveal a modern tale of great deeds of the race—an epos of applied science.

Its story began the day when chemistry taught us how indispensable are the nitrogeneous substances for the growth of all living beings.

### Nitrogen Fertilizers

Generally speaking, the most expensive food-stuffs are precisely those which contain most nitrogen; for the simple reason that there is, and always has been, at some time or another, a shortage of nitrogeneous foods in the world. Agriculture furnishes us these proteid- or nitrogen-containing bodies, whether we eat them directly as vegatable products, or indirectly as animals which have assimilated the proteids from plants.

It so happens, however, that, by our ill-balanced methods of agriculture, we take nitrogen from the soil much faster than it is supplied to the soil through natural agencies. We have tried to remedy this discrepancy by enriching the soil with manure or other fertilizers, but this has been found totally insufficient, especially with our methods of intensive culture—our fields want more nitrogen.

So agriculture has been looking anxiously around to find new sources of nitrogen fertilizer. For a short time, an excellent supply was found in the guano deposits of Peru; but this material was used up so eagerly that the supply lasted only a very few years. In the meantime, the ammonium salts recovered from the by-products of the gas-works have come into steady use as nitrogen fertilizer. But, here again, the supply is entirely insufficient, and during the later period our main reliance has been placed on the natural beds of sodium nitrate, which are found in the desert regions of Chile. This has been, of late, our principal source of nitrogen for agriculture, as well as for the many industries which require saltpeter or nitric acid.

In 1898, Sir William Crookes, in his memorable presidential address before the British Association for the Advancement of Science, called our attention to the threatening fact that, at the increasing rate of consumption, the nitrate beds of Chile would be exhausted before the middle of this century. Here was a warning—an alarm call—raised to the human race by one of the deepest scientific thinkers of our generation. It meant no more nor less than that before long our race would be confronted with nitrogen starvation.

In a given country, all other conditions being equal, the abundance or the lack of nitrogen available for nutrition is a paramount factor in the degree of general welfare, or of physical decadence. The less nitrogen there is available as food-stuffs, the nearer the population is to starvation. The great famines in such nitrogen-deficient countries as India and China and Russia are sad examples of nitrogen starvation.

And yet, nitrogen, as such, is so abundant in nature that it constitutes four-fifths of the air we breathe. Every square mile of our atmosphere contains nitrogen enough to satisfy our total present consumption for over half a century. However, this nitrogen is unavailable as long as we do not find means to make it enter into some suitable chemical combination. Moreover, nitrogen was generally considered inactive, and inert, because it does not enter readily in chemical combination.

William Crookes' disquieting message of rapidly approaching nitrogen starvation did not cause much worry to politicians—they seldom look so far ahead into the future. But, to the men of science, it rang like a reproach to the human race. Here, then, we were in possession of an inexhaustible store of nitrogen in the air, and yet, unless we found some practical means for tying some of it into a suitable chemical combination, we should soon be in a position similar to that of a shipwrecked sailor, drifting around on an immense ocean of brine, and yet slowly dying for lack of drinking water.

### Nitric Acid from Air by Means of Electric Discharges

As a guiding beacon, there was, however, that simple experiment, carried out in a little glass tube, as far back as 1785, by both Cavendish and Priestly, which showed that if electric sparks were passed through air, the oxygen thereof was able to burn some of the nitrogen and to engender nitrous vapors.

This seemingly unimportant laboratory curiosity, so long dormant in the text-books, was made a starting point by Charles S. Bradley and D. R. Lovejoy, in Niagara Falls, for creating the first industrial apparatus for converting the nitrogen of the air into nitric acid by means of the electric arc.

As early as 1902, they published their results as well as the details of their apparatus. Although they operated only one full-sized unit, they demonstrated conclusively that nitric acid could thus be produced from the air in unlimited quantities. We shall examine later the reasons why this pioneer enterprise did not prove a commercial success; but to these two American inventors belongs, undoubtedly, the credit of having furnished the first answer to the distress call of Sir William Crookes.

In the meantime many other investigators were at work at the same problem, and soon from Norway's abundant water-falls came the news that Birkeland and Eyde had solved successfully, and on a commercial scale, the same problem by a differently constructed apparatus. The Germans, too, were working on the same subject, and we heard that Schoenherr, also Pauling, had evolved still other methods, all, however, based on the Cavendish-Priestly principle of oxidation of nitrogen. In Norway alone the artificial saltpeter factories use now, day and night, over 200,000 electrical horse-power, which will soon be doubled; while a further addition is contemplated which will bring the volume of electric current consumed to about 500,000 horse-power. The capital invested at present in these works amounts to $27,000,000.

### Cyanamide

Frank and Caro, in Germany, succeeded in creating another profitable industrial process whereby nitrogen could be fixed by carbide of calcium, which converts it into calcium cyanamide, an excellent fertilizer by itself. By the action of steam on cyanamide, ammonia is produced, or it can be made the starting point of the manufacture of cyanides, so profusely used for the treatment of gold and silver ores.

Although the synthetic nitrates have found a field of their own, their utilization for fertilizers is smaller than that of the cyanamide; and the latter industry represents to-day, an investment of about $30,000,000, with three factories in Germany, two in Norway, two in Sweden, one in France, one in Switzerland, two in Italy, one in Austria, one in Japan, one in Canada, but not any in the United States. The total output of cyanamide is valued at $15,000,000 yearly and employs 200,000 horse-power, and preparations are made at almost every existing plant for further extensions. An English company is contemplating the application of 1,000,000 horse-power to the production of cyanamide and its derivatives, 600,000 of which have been secured in Norway and 400,000 in Iceland.

### Nitride Processes

But still other processes are being developed, based on the fact that certain metals or metalloids can absorb nitrogen, and can thus be converted into nitrides; the latter can either be used directly as fertilizers or they can be made to produce ammonia under suitable treatment.

The most important of these nitrade processes seems to be that of Serpek, who, in his experimental factory at Niedermorschweiler, succeeded in obtaining aluminum nitrade in almost theoretical quantities, with the use of an amount of electrical energy eight times less than that needed for the Birkeland-Eyde process and one half less than for the cyanamide process, the results being calculated for equal weights of "fixed" nitrogen.

A French company has taken up the commercial application of this process which can furnish, besides ammonia, pure alumina for the manufacture of aluminum metal.

### Haber's Ammonia Process

An exceptionally ingenious process for the direct synthesis of ammonia, by the direct union of hydrogen with nitrogen, has been developed by Haber in conjunction with the chemists and engineers of the Badische Aniline & Soda Fabrik.

The process has the advantage that it is not, like the other nitrogen-fixation processes, paramountly dependent upon cheap power; for this reason, if for no other, it seems to be destined to a more ready application. The fact that the group of the three German chemical companies which control the process have sold out their former holdings in the Norwegian enterprises to a Norwegian-French group, and are now devoting their energies to the commercial installation of the Haber process, has quite some significance as to expectation for the future.

### The Future of Nitrogen-Fixation Processes

The question naturally arises: Will there be an overproduction and will these different rival processes not kill each other in slaughtering prices beyond remunerative production?

As to over-production, we should bear in mind that nitrogen fertilizers are already used at the rate of about $200,000,000 worth a year, and that any decrease in price, and, more particularly, better education in farming, will probably lead to an enormously increased consumption. It is worth mentioning here that in 1825, the first shipload of Chile saltpeter, which was sent to Europe, could find no buyer, and was finally thrown into the sea as useless material.

Then again, processes for nitric acid and processes for ammonia, instead of interfering, are supplementary to each other, because the world needs ammonia and ammonium salts, as well as nitric acid or nitrates.

It should be pointed out, also, that ultimately, the production of ammonium nitrate may prove the most desirable method so as to minimize freight; for this salt contains much more nitrogen to the ton than is the case with the more bulky calcium-salt, under which form synthetic nitrates are now put into the market.

Before leaving this subject, let us examine why Bradley and Lovejoy's efforts came to a standstill where others succeeded.

First of all, the cost of power at Niagara Falls is three to five times higher than in Norway, and although at the time this was not strictly prohibitive for the manufacture of nitric acid, it was entirely beyond hope for the production of fertilizers. The relatively high cost of power in our country is the reason why the cyanamide enterprise had to locate on the Canadian side of Niagara Falls, and why, up till now, outside of an experimental plant in the South (a 4,000 horse-power installation in North Carolina, using the Pauling process), the whole United States has not a single synthetic nitrogen fertilizer works.

The yields of the Bradley-Lovejoy apparatus were rather good. They succeeded in converting as much as two and one-half per cent of the air, which is somewhat better than their successors are able to accomplish.

But their units, 12 kilowatts, were very much smaller than the 1,000 to 3,000 kilowatts now used in Norway; they were also more delicate to handle, all of which made installation and operation considerably more expensive.

However this was the natural phase through which any pioneer industrial development has to go, and it is more than probable that in the natural order of events, these imperfections would have been eliminated.

But the killing stroke came when financial support was suddenly withdrawn.

### Necessity of Scientific Team-Work and Good Financial Backing

In the successful solution of similar industrial problems, the originators in Europe were not only backed by scientifically well-advised bankers, but they were helped to the rapid solution of all the side problems by a group of specially selected scientific collaborators, as well as by all the resourcefulness of well-established chemical enterprises.

That such conditions are possible in the United States has been demonstrated by the splendid team-work which led to the development of the modern tungsten lamp in the research laboratories of the General Electric Company, and to the development of the Tesla polyphase motor, by the group of engineers of the Westinghouse Company.

True, there are endless subjects of research and development which can be brought to success by the efforts of single independent inventors, but there are some problems of applied science which are so vast, so much surrounded with ramifying difficulties, that no one man, or two men, however exceptional, can either furnish the brains or the money necessary for leading to success within a reasonable time. For such special problems, the rapid cooperation of numerous experts and the financial resources of large establishments are indispensable.

All these examples of the struggle for efficiency and improvement demonstrate why, in industrial chemistry, the question of *dollars and cents* has to be taken very much into consideration.

From this standpoint at least, the "dollars and cents" argument can be interpreted as a symptom of industrial efficiency, and thus, the definition sounds no longer as a reproach. With some allowable degree of accuracy, it formulates one of the economic aspects of any acceptable industrial chemical process.

Indeed, barring special conditions, as, for instance, incompetent or reckless management, unfair competition, monopolies, or other artificial privileges, the money success of a chemical process is the cash plebiscite of approval of the consumers. It is bound, after a time at least, to weed out the inefficient methods.

### Influence of Secondary Factors in Chemical Processes

Some chemists, who have little or no experience with industrial enterprises, are too much over-inclined to judge a chemical process exclusively from the standpoint of the chemical reactions involved therein, without sufficient regard to engineering difficulties, financial requirements, labor problems, market and trade conditions, rapid development of the art involving frequent disturbing improvements in methods and expensive changes in equipment, advantages or disadvantages of the location of the plant, and other conditions so numerous and variable that many of them can hardly be foreseen even by men of experience.

And yet, these seemingly secondary considerations most of the time become the deciding factor of success or failure of an otherwise well-conceived chemical process.

The cost of transportation alone will, frequently, decide whether a certain chemical process is economically possible or not. For instance, the big Washoe Smelter, in Montana, wastes enough sulphuric-dioxide gas to make daily 1,800 tons of sulphuric acid, but that smelter is too far distant from any possible market for such a quantity of otherwise valuable material.

### Natural Deposits of Soda

Another example of the kind is found in the natural deposits of soda or soda lakes in California. One of these soda lakes contains from thirty to forty-two million tons of soda. Here is a natural source of supply which would be ample to satisfy the world's demand for many years to come. Similar deposits exist in other parts of the world, but the cost of transportation to a sufficiently large and profitable market is so exorbitant that, in the meantime, it is cheaper to erect at more convenient points expensive chemical works in which soda is made chemically and from where the market can be supplied more profitably.

In addition, we can cite the artificial nitrate processes in Norway, which, notwithstanding their low efficiency and expensive installation, can furnish nitrate in competition with the natural nitrate beds of Chile, because the latter are hampered by the cost of extraction from the soil where fuel for crystallization is expensive, in addition to the considerable cost of freight.

### Leblanc Soda

But there is no better example illustrating the far-reaching effect of seemingly secondary conditions upon the success of a chemical process than the history of the Leblanc soda process.

This famous process was the forerunner of chemical industry. For almost a century it dominated the enormous group of industries of heavy chemicals, so expressively called by the French "La Grande Industrie Chimique," and now we are witnesses of the lingering death agonies of this chemical colossus. Through the Leblanc process, large fortunes have been made and lost; but even after its death, it will leave a treasure of information to science and chemical engineering, the value of which can hardly be overestimated.

Here, then, is a very well worked-out process admirably studied in all its details,which, in its heroic struggle for existence, has drawn upon every conceivable resources of ingenuity furnished by the most learned chemists and the most skilful engineers, who succeeded in bringing it to an extraordinary degree of perfection, and which, nevertheless, has to succumb before inexorable, although seemingly secondary, conditions.

### Solvay Process

Strange to say, its competitor, the Solvay process, entered into the arena after a succession of failures. When Solvay, as a young man, took up this process, he was, himself, totally ignorant of the fact that no less than about a dozen able chemists had invented and reinvented the very reaction on whicht he had pinned his faith; that, furthermore, some had tried it on a commercial scale, and had, in every instance, encountered failure. At that time, all this must, unodubtedly, have been to young Solvay a revelation sufficient to dishearten almost anybody. But he had one predominant thought to which he clung as a last hope of success, and which would probably have escaped most chemists; he reasoned that, in this process, he starts from two watery solutions, which, when brought together, precipitate a dry product, bicarbonate of soda; in the Leblanc process, the raw materials must be melted together with the use of expensive fuel, after which the mass is dissolved in water, losing all these valuable heat units, while more heat has again to be applied to evaporate to dryness.

After all, most of the weakness of the Leblanc process resides in the greater consumption of fuel. But the cost of fuel, here again, is determined by freight rates. This is so true that we find that the last few Leblanc works which manage to keep alive are exactly those which are situated near unusually favorable shipping points, where they can obtain cheap fuel, as well as cheap raw materials, and whence they can most advantageously reach certain profitable markets.

But another tremendous handicap of the Leblanc process is that it gives as one of its by-products, hydrochloric acid. Profitable use for this acid, as such, can be found only to a limited extent. It is true that hydrochloric acid could be used in much larger quantities for many purposes where sulphuric acid is used now, but it has, against sulphuric acid, a great freight disadvantage. In its commercially available condition, it is an aqueous solution, containing only about one third of real acid, so that the transportation of one ton of acid practically involves the extra cost of freight of about two tons of water. Furthermore, the transportation of hydrochloric acid in anything but glass carboys involves very difficult problems in itself, so that the market for hydrochloric acid remains always within a relatively small zone from its point of production. However, for a while at least, an outlet for this hydrochloric acid was found by converting it into a dry material which can easily be transported; namely, chloride of lime or bleaching-powder.

### Electrolytic Processes a New Competitor

The amount of bleaching-powder consumed in the world practically dictated the limited extent to which the Leblanc process could be profitably worked in competition with the Solvay process. But even this outlet has been blocked during these later years by the advent of the electrolytic alkali processes, which have sprung up successfully in several countries, and which give as a cheap by-product, chlorine, which is directly converted into chloride of lime.

To-day, any process which involves the production of large quantites of hydrochloric acid, beyond what the market can absorb as such, or as derivatives thereof, becomes a positive detriment, and foretells failure of the process. Even if we could afford to lose all the acid, the disposal of large quantities thereof conflicts immediately with laws and ordinances relative to the pollution of the atmosphere or streams, or the rights of neighbors, and occasions expensive damage suits.

Whatever is said about hydrochloric acid applies to some extent to chlorine, produced in the electrolytic manufacture of caustic soda. Here again, the development of the latter industry is limited, primarily, by the amount of chlorine which the market, as such, or as chlorinated products, can absorb.

At any rate, chlorine can be produced so much cheaper by electrolytic caustic alkali processes than formerly, and in the meantime the market price of chloride of lime has already been cut about in half.

In as far as the rather young electrolytic alkali industry has taken a considerable development in the United States, let us examine it somewhat nearer.

At present, the world's production of chloride of lime approximates about half a million tons.

We used to import all our chloride of lime from Europe, until about fifteen years ago, when the first successful electrolytic alkali works were started at Niagara Falls. That ingenious mercury cell of Hamilton Y. Castner—a pupil of Professor Chandler and one of the illustrious sons of the Columbia School of Mines—was first used, and his process still furnishes a large part of all the electrolytic caustic soda and chlorine manufactured here and abroad.

At present, about 30,000 electrical horse-power are employed uninterruptedly for the different processes used in the United States, and our home production has increased to the point where, instead of importing chloride of lime, we shall soon be compelled to export our surplus production.

It looks now as if, for the moment at least, any sudden considerable increase in the production of chloride of lime would lead to over-production until new channels of consumption of chloride of lime or other chlorine products can be found.

However, new uses for chlorine are being found every day. The very fact that commercial hydrochloric acid of exceptional purity is now being manufactured in Niagara Falls by starting from chlorine, indicates clearly that conditions are being reversed; no longer than a few years ago, when chlorine was manufactured exclusively by means of hydrochloric acid, this would have sounded like a paradox.

### Organic Chlorine Products

The consumption of chlorine for the preparation of organic chlorination products utilized in the dye-stuff industry, is also increasing continually, and its use for the manufacture of tetrachloride of carbon and so-called acetylen chlorination products, has reached importance.

There is probably a much overlooked but wider opening for chlorinated solvents in the fact that ethylen-gas can be prepared now at considerably lower cost than acetylen, and that ethylen-chloride, or the old known "Dutch Liquid," is an unusually good solvent. It has, furthermore, the great advantage that its specific gravity is not too high, and its boiling point, too, is about the right temperature. It ought to be possible to make it at such a low price that it would find endless applications where the use of other chlorination solvents has thus far been impossible.

The chlorination of ores for certain metallurgical processes may eventually open a still larger field of consumption for chlorine.

In the meantime, liquified chlorine gas, obtained by great compression, or by intense refrigeration, has become an important article of commerce, which can be transported in strong steel cylinders. Its main utilization resides in the manufacture of tin chloride by the Goldschmidt process for reclaiming tin-scrap. It is finding, also, increased applications as a bleaching agent and for the purification of drinking water, as well as for the manufacture of various chlorination products.

Its great handicap for rapid introduction is again the question of freight, where heavy and expensive containers become indispensable.

In most cases the transportation problem of chlorine is solved more economically by handling it as chloride of lime, which, after all, represents chlorine or oxygen in solid form, easily transportable.

It would seem as if the freight difficulty could easily be eliminated by producing the chlorine right at the spot of consumption. But this is not always so simple as it may appear. To begin with, the cost of an efficient plant for any electrolytic operation is always unusually high as compared to other chemical equipments. Then, also, small electrolytic alkali plants are not profitable to operate. Furthermore, the conditions for producing cheap chlorine depend on many different factors, which all have to coordinate advantageously; for instance, cheap power, cheap fuel and cheap raw materials are essential, while, at the same time, a profitable outlet must be found for the caustic soda.

Lately, there has been a considerable reduction of the market price of caustic soda; all this may have for effect that the less efficient electrolytic processes will gradually be eliminated; although this may not necessarily be the case for smaller plants which do not compete in the open market, but consume their own output for some special purpose.

### Advantages and Disadvantages of Different Types of Electrolytic Alkali Cells

Several distinct types of electrolytic cells are now in successful use, but experience seems to demonstrate that the so-called diaphragm cells are cheapest to construct and to operate, provided, however, no exception be taken to the fact that the caustic soda obtained from diaphragm cells always contains some sodium chloride, usually varying from two or three per cent, which it is not practical to eliminate, but which for almost all purposes does not interfere in the least with its commercial use.

Mercury cells give a much purer caustic soda, and this may, in some cases, compensate for their more expensive equipment and operation. Moreover, there are some purposes where the initial caustic solution of rather high concentration, produced directly in these cells, can be used as it is without further treatment, thus obviating further concentration and cost of fuel.

The expenses for evaporation and elimination of salt from the raw caustic solutions increase to an exaggerated extent with some types of diaphragm cells, which produce only very weak caustic liquors. This is also the case with the so-called "gravity cell," sometimes called the "bell type," or "Aussig type," of cell. But these gravity cells have the merit of dispensing with the delicate and expensive problem of diaphragms. On the other hand, their units are very small, and, on this account, they necessitate a rather complicated installation, occupying an unusually large floor space and expensive buildings.

The general tendency is now toward cells which can be used in very large units, which can be housed economically, and of which the general cost of maintenance and renewal is small; some of the modern types of diaphragm cells are now successfully operating with 3000 to 5000 amperes per cell.

As to the possible future improvements in electrolytic alkali cells, we should mention that in some types the current efficiencies have practically reached their maximum and average ampere efficiencies as high as 95 to 97 per cent have been obtained in continuous practise. The main difficulty is to reinforce these favorable results by the use of lower voltage, without making the units unnecessarily bulky, or expensive in construction, or in maintenance, all factors which soon outweigh any intended saving of electric current.

Here, more than in any other branch of chemical engineering, it is easy enough to determine how "good" a cell is on a limited trial, but it takes expensive, long continuous use on a full commercial scale, running uninterruptedly day and night for years, to find out how "bad" it is for real commercial practise.

### Cheap Power Not the Only Factor

In relation to the electrolytic alkali industry, a great mistake is frequently committed by considering the question of power as paramount; true enough, cheap power is very important, almost essential, but certainly it is not everything. There have been cases where it was found much cheaper in the end to pay almost double for electric current in a certain locality, than in another site not far distant from the first, for the simple reason that the cheaper power supply was hampered by frequent interruptions and expensive disturbances, which more than offset any possible saving in cost of power.

In further corroboration, it is well known that some of the most successful electrolytic soda manufacturers have found it to their advantage to sacrifice power by running their cells at decidedly higher voltage than is strictly necessary—which simply means consuming more power—and this in order to be able to use higher current densities, thereby increasing considerably the output of the same size units, and thus economizing on the general cost of plant operation. Here is one of the ever recurring instances in chemical manufacturing where it becomes more advantageous to sacrifice apparent theoretical efficiency in favor of industrial expediency.

All this does not diminish the fact that the larger electrochemical industries can only thrive where cheap power is available.

### Importance of Cheap Power for Electrochemical Processes

Modern progress of electrical engineering has given us the means to utilize socalled natural powers; until now, however, we have only availed ourselves of the water-power developed from rivers, lakes and waterfalls. As far as large electric power generation is concerned, the use of the wind, or the tide, or the heat of the sun, represents, up till now, nothing much beyond a mere hope of future possibilities.

In the meantime, it so happens, unfortunately, that many of the most abundant water-powers of the world are situated in places of difficult access, far removed from the zone of possible utilization.

But, precisely on this account, it would appear, at first sight, as if the United States, with some of her big water-powers situated nearer to active centers of consumption, would be in an exceptionally favorable condition for the development of electrochemical industries. On closer examination, we find, however, that the cost of water-power, as sold to manufacturers, is, in general, much higher than might be expected; at any rate, it is considerably more expensive than the cost of electric power utilized in the Norway nitrate enterprises.

This is principally due to the fact that in the United States, water-power, before it is utilized by the electrolytic manufacturer, has already to pay one, two and sometimes three, profits, to as many intermediate interests, which act as so many middlemen between the original water-power and the consumer. Only in such instances as in Norway, where the electrochemical enterprise and the development of the water-power are practically in the same hands, can electric current be calculated at its real cheapest cost.

Neither should the fact be overlooked that the best of our water-powers in the east are situated rather far inland. Although this does not matter much for the home market, it puts us at a decided disadvantage for the exportation of manufactured goods, in comparison again with Norway, where the electrolytic plants are situated quite close to a good sea-harbor open in all seasons.

### Increasing Use of Gas Power

Some electrochemical enterprises require cheap fuel just as much as cheap power; and, on this account, it has proved sometimes more advantageous to dispense entirely with water-power by generating gas for fuel as well as for power from cheap coal or still cheaper peat.

At present most of our ways of using coal are still cumbersome and wasteful, although several efficient methods have been developed which some day will probably be used almost exclusively, principally in such places where lower grades of cheap coal are obtainable.

I refer here particularly to the valuable pioneer work of that great industrial chemist, Mond, on cheap water-gas production, by the use of limited amount of air in conjunction with water vapor.

More recently this process has been extended by Caro, Frank and others, to the direct conversion of undried peat into fuel-gas.

By the use of these processes, peat or lower grades of coal, totally unsuitable for other purposes, containing, in some instances, as much as 60 to 70 per cent of incombustible constituents, can be used to good advantage in the production of fuel for power generation.

Whether Mond-gas will ever be found advantageous for distribution to long distances, is questionable, because its heating value per cubic foot is rather less than that of ordinary water-gas, but this does not interfere with its efficient use in internal combustion engines.

In general, our methods for producing or utilizing gas in our cities do scant justice to the extended opportunities indicated by our newer knowledge.

Good fuel-gas could be manufactured and distributed to the individual household consumer at considerably cheaper rates, if it were not for antiquated municipal specifications, which keep on prescribing photometric tests instead of insisting on standards of fuel value, which makes the cost of production unnecessarily high, and disregards the fact that for lighting, the Welsbach mantle has rendered obsolete the use of highly carbureted gas as a bare flame. But for those unfortunate specifications, cheap fuel-gas might be produced at some advantageous central point, where very cheap coal is available; such heating gas could be distributed to every house and every factory, where it could be used cleanly and advantageously, like natural gas, doing away at once with the black coal smoke nuisance, which now practically compels a city like New York to use nothing but the more expensive grades of anthracite coal. It would eliminate, at the same time, all the bother and expense caused through the clumsy and expensive methods of transportation and handling of coal and ashes; it would relieve us from many unnecessary middlemen which now exist between coal and its final consumer.

### New Power Centers to Compete with Water-Power

The newer large-sized internal combustion engines are introducing increasing opportunities for new centers of power production where waste gas or blast-furnaces or coke-ovens, or where deposits of inferior coal or peat, are available.

If such centers are situated near tide-water, this may render them still more advantageous for some electrochemical industries, which, until now, were compelled to locate near some inland water-powers.

Nor should we overlook the fact that the newer methods for the production of cheap fuel-gas offer excellent opportunities for an increased production of valuable tar by-products, and more particularly of ammonium salts; the latter would help to a not inconsiderable extent in furnishing more nitrogen fertilizer.

It is somewhat remarkable that a greater effort has already been made to start the industrial synthesis of nitrogen products than to economize all these hitherto wasted sources of ammonia.

### Our Unbalanced Methods of Agriculture

In fact, science indicates still other ways, somewhat of a more radical nature, for correcting the nitrogen deficiencies in relation to our food supply.

Indeed, if we look at this matter from a much broader standpoint, we may find that, after all, the shortage of nitrogen in the world is attributable to a large extent to our rather one-sided system of agriculture. We do not sufficiently take advantage of the fact that certain plants, for instance those of the group of Leguminosæ, have the valuable property of easily assimilating nitrogen from the air, without the necessity of nitrogen fertilizers.

In this way, therefore, the culture of certain Leguminosæ can insure enough nitrogen for the soil so that, in rotation with nitrogen consuming crops, like wheat, we could dispense with the necessity of supplying any artificial nitrogen fertilizers.

The present nitrogen deficiency is influenced further by two other causes:

The first cause is our unnecessary exaggerated meat diet, in which we try to find our proteid requirements, and which compels us to raise so many cattle, while the amount of land which feeds one head of cattle could furnish, if properly cultivated, abundant vegetable food for a family of five.

The second cause is our insufficient knowledge of the way to grow and prepare for human food just those vegetables which are richest in proteids. Unfortunately, it so happens that exactly such plants as, for instance, the soy-bean are not by any means easily rendered palatable and digestible; while any savage can eat raw meat, or can readily cook, boil or roast it for consumption.

On this subject, we can learn much from some Eastern people, like the Japanese, who have become experts in the art of preparing a variety of agreeable food products from that refractory soy-bean, which contains such an astonishingly large amount of nutritious proteids, and which, long ago, became for Japan a wholesome, staple article of diet.

But on this subject, the Western races have not yet progressed much beyond the point of preparing cattle-feed and paint oil from the soy-bean, although the more extended culture of this, or similar plants, might easily work about a revolution in our agricultural economies.

### Agriculture a Branch of Industrial Chemistry

Agriculture, after all, is nothing but a very important branch of industrial chemistry, although most people seem to ignore the fact that the whole prosperity of agriculture is based on the success of that photochemical reaction which, under the influence of the light of the sun, causes the carbon dioxide of the air to be assilimated by the chlorophyl of the plant.

### Possibilities of Photo-Chemistry

It is not impossible that photochemistry, which hitherto has busied itself almost exclusively within the narrow limits of the art of making photographic images, will, some day, attain a development of usefulness at least as important as all other branches of physical chemistry. In this broader sense photochemistry seems an inviting subject for the agricultural chemist. The possible rewards in store in this almost virgin field may, in their turn, by that effect of superinduction between industry and science, bring about a rapid development similar to what we have witnessed in the advancement of electricity, as well as chemistry, which both began to progress by bounds and leaps, way ahead of other sciences, as soon as their growing industrial applications put a high premium on further research.

Photochemistry may allow us some day to obtain chemical effects hitherto undreamed of. In general, the action of light in chemical reactions seems incomparably less brutal than all means used heretofore in chemistry. This is the probable secret of the subtle chemical syntheses which happen in plant life. To try to duplicate these delicate reactions of nature by our present methods of high temperatures, electrolysis, strong chemicals and other similar torture-processes, seems like trying to imitate a masterpiece of Gounod by exploding a dynamite cartride between the strings of a piano.

### Some Problems for the Future

But there are endless other directions for scientific research, relating to industrial applications, which, until now, do not seem to have received sufficient attention.

For instance, from a chemical standpoint, the richest chemical enterprise of the United States, the petroleum industry, has hitherto chiefly busied itself with a rather primitive treatment of this valuable raw material, and little or no attention has been paid to any methods for transforming at least a part of these hydrocarbons into more ennobled products of commerce than mere fuel or illuminants.

A hint as to the enormous possibilities which may be in store in that direction is suggested by the recent work in Germany and England on synthetic rubber; the only factor which prevents extending the laboratory synthesis of rubber into an immense industrial undertaking is that we have not yet learned how to make cheaply the isoprene or other similar non-saturated hydro-carbons which are the starting point in the process which changes their molecules, by polymerization, into rubber.

Nor has our science begun to find the best uses for such inexpensive and never exhaustible vegetable products as cellulose or starch. Quite true, several important manufacturers, like that of paper nitro-cellulose, glucose, alcohol, vinegar and some others, have been built on it; but to the chemist at least, it seems as if a much greater development is possible in the cheaper and more extended production of artificial fiber. Although we have succeeded in making so-called artificial silk, this article is still very expensive; furthermore, we have not yet produced a cheap, good, artificial fiber of the quality of wool.

If we have made ourselves independent of Chile for our nitrogen supply, we are still absolutely at the mercy of the Stassfurt mines in Germany for our requirements of soluble potash-salts, which are just as necessary for agriculture. Shall we succeed in utilizing some of the proposed methods for converting that abundant supply of feldspar, or other insoluble potash-bearing rocks, into soluble potash-salts by combining the expensive heat treatment with the production of another material like cement, which would render the cost of fuel less exorbitant? Or shall the problem be solved in setting free soluble potassium salts as a by-product in a reaction engendering other staple products consumed in large quantities?

### Our Ignorance Relative to Constitution of the Globe

We have several astonishingly conflicting theories about the constitution of the center of the globe, but we have not yet developed the means to penetrate the world's crust beyond some deep mines—merely an imperceptible faint scratch on the surface—and in the meantime we keep on guessing, while to-day astronomers know already more about the surface of the planet Mars than we know about the interior of the globe on which we live.

Nor have we learned to develop or utilize the tremendous pressures under which most minerals have been formed, and still less do we possess the means to try these pressures, in conjunction with intensely high temperatures.

No end of work is in store for the research chemist, as well as for the chemical engineer, who can think by himself, without always following the beaten track. We are only at the beginning of our successes, and yet, when we stop to look back to see what has been accomplished during the last generations, that big jump from the rule-of-thumb to applied science is nothing short of marvelous.

Whoever is acquainted with the condition of human thought to-day must find it strange, after all, that scarcely seventy years ago, Mayer met with derision even amongst the scientists of the time, when he announced to the world that simple but fundamental principle of the conservation of energy.

We can hardly conceive that just about the time the Columbia School of Mines was founded, Liebig was still ridiculing Pasteur's ideas on the intervention of microorganisms in fermentation, which have proved so fecund in the most epoch-making applications in science, medicine, surgery and sanitation, as well as in many industries.

Fortunately, true science, contrary to other human avocations, recognizes nobody as an "authority," and is willing to change her beliefs as often as better studied facts warrant it; this difference has been the most vital cause of her never ceasing progress.

To the younger generation, surrounded with research laboratories everywhere, it may cause astonishment to learn that scarcely fifty years ago, that great benefactor of humanity, Pasteur, was still repeating his pathetic pleadings with the French government to give him more suitable quarters than a damp, poorly lighted basement, in which he was compelled to carry on his research; and this was, then, the condition of affairs of no less a place than Paris, the same Paris that was spending, just at that time, endless millions for the building of her new Opera-Palace.

### Reason for America's Slow Development of Chemical Industry

Such facts should not be overlooked by those who might think that America has been too slow in fostering chemical research.

If the United States has not participated as early as some European countries in the development of industrial chemistry, this was chiefly because conditions here were so totally different from those of nations like Germany, England and France, that they did not warrant any such premature efforts.

In a country so full of primary resources, agriculture, forests, mines and the more elementary industries directly connected therewith, as well as the problems of transportation, appealed more urgently to American intellectual men of enterprise.

Why should anybody here have tried to introduce new, difficult or risky chemical industries, when on every side more urgently important fields of enterprise were inviting all men of initiative?

Chemical industries develop along the lines furnished by the most immediate needs of a country. Our sulphuric acid industry, which can boast to-day of a yearly production of about three million tons, had to begin in an exceedingly humble way, and the first small amounts of sulphuric acid manufactured here found a very scant outlet.

It required the growth of such fields of application as petroleum refining, superphosphates, explosives and others, before the sulphuric acid industry could grow to what it is to-day.

### Exports and Imports Between the United States and Germany

At present, similar influences are still dominating our chemical industries; they are generally directed to the mass production of partly manufactured articles. This allows us to export, at present, to Germany, chemicals in crude form, but in greater value than the total sum of all the chemical products we are importing from her; although it cannot be denied that a considerable part of our imports are products like alizarine, indigo, aniline dyes and similar synthetic products which require higher chemical manufacturing skill.

In this connection it may be pointed out that our exports of oleomargarine, to Germany alone, are about equivalent to our imports of aniline dyes.

### Some Chemical Industries in Which the United States Was Pioneer

But all this does not alter the fact that in several important chemical industries the United States has been a pioneer. Such flourishing enterprises as that of the artificial abrasives, carborundum and alundum, calcium carbide, aluminum and many others, testify how soon we have learned to avail ourselves of some of our water-power.

One of the most important chemical industries of the world, the sulphite cellulose industry, of which the total annual production amounts to three and a half million tons, was originated and developed by a chemist in Philadelphia, B. C. Tilgman. But its further development was stopped for awhile on account of the same old trouble, lack of funds, after $40,000 were spent, until some years later, it was taken up again in Europe and reintroduced in the United States, where it has developed to an annual production of over a million tons.

What has been accomplished in America in chemical enterprises and what is going on now in industrial research has been brilliantly set forth by Mr. Arthur D. Little.

### Early Beginning of Study of Chemistry in the United States

Nor at any time in the history of the United States was chemistry neglected in this country; this has recently been brought to light in the most convincing manner by Professor Edgar F. Smith, of Philadelphia.

The altruistic fervor of that little group of earlier American chemists, who, in 1792, founded the Chemical Society of Philadelphia (probably the very first chemical society in the world), and in 1811, the Columbia Chemical Society of Philadelphia, is best illustrated by an extract of one of the addresses read at their meeting in 1798:

"The only true basis on which the independence of our country can rest are agriculture and manufactures. To the promotion of these nothing tends in a higher degree than chemistry. It is this science which teaches man how to correct the bad qualities of the land he cultivates by a proper application of the various species of manure, and it is by means of a knowledge of this science that he is enabled to pursue the metals through the various forms they put on in the earth, separate them from substances which render them useless, and at length manufacture them into the various forms for use and ornament in which we see them. If such are the effects of chemistry, how much should the wish for its promotion be excited in the breast of every American! It is to a general diffusion of knowledge of this science, next to the virtue of our countrymen, that we are to look for the firm establishment of our independence. And may your endeavors, gentlemen, in this cause, entitle you to the gratitude of your fellow-citizens."

This early scientific spirit has been kept alive throughout the following century by such American chemists as Robert Hare, E. N. Horsford, Wolcott Gibbs, Sterry Hunt, Lawrence Smith, Carey Lea, Josiah P. Cooke, John W. Draper, Willard Gibbs and many others still living.

Present conditions in America can be measured by the fact that the American Chemical Society alone has over seven thousand members, and the Chemists' Club of New York has more than a thousand members, without counting the more specialized chemical organizations, equally active, like the American Institute of Chemical Engineers, the American Electrochemical Society and many others.

During the later years chemical research is going on with increasing vigor, more especially in relation to chemical problems presented by enterprises which at first sight seem rather remote from the so-called chemical industry.

### Research in America

But the most striking symptom of newer times is that some wealthy men of America are rivaling each other in the endowment of scientific research on a scale never undertaken before, and that the scientific departments of our government are enlarging their scope of usefulness at a rapid rate.

But we are merely at the threshold of that new era where we shall learn better to use exact knowledge and efficiency to bring greater happiness and broader opportunities to all.

However imposing may appear the institutions founded by the Nobels, the Solvays, the Monds, the Carnegies, the Rockefellers and others, each of them is only a puny effort to what is bound to come when governments will do their full share. Fancy that if, for instance, the Rockefeller Institute is spending to good advantage about half a million dollars per annum for medical research, the chewing-gum bill of the United States alone would easily support half a dozen Rockefeller Institutes; and what a mere insignificant little trickle all these research funds amount to, if we have the courage to compare them to that powerful gushing stream of money which yearly drains the war budget of all nations.

In the meantime the man of science is patient and continues his work steadily, if somewhat slowly, with the mean hitherto at his disposal. His patience is inspired by the thought that he is not working for to-day, but for to-morrow. He is well aware that he is still surrounded by too many "men of yesterday," who delay the results of his work.

### Efficiency vs. Waste

Sometimes, however, he may feel discouraged that the very efficiency he has succeeded in reaching at the cost of so many painstaking efforts, in the economical production of such an article of endlessly possible uses, as Portland cement, is hopelessly lost many times over and over again, by the inefficiency, waste and graft of middlemen and political contractors, by the time it gets on our public roads, or in our public buildings. Sometimes the chaos of ignorant brutal waste which surrounds him everywhere may try his patience. Then, again, he has a vision that he is planting a tree which will blossom for his children and will bear fruit for his grandchildren.

### New Type of Man Evolved by Scientific Education

In the meantime, industrial chemistry, like all other applications of science, has gradually called into the world an increasing number of men of newer tendencies, men who bear in mind the future rather than the past, who have acquired the habit of thinking by well-established facts, instead of by words, of aiming at efficiency instead of striking haphazard at ill-defined purposes. Our various engineering schools, our universities, are turning them out in ever-increasing numbers, and better and better prepared for their work. Their very training has fitted them out to become the most broad-minded progressive citizens.

However, their sphere of action, until now, seldom goes beyond that of private technical enterprises for private gain. And yet, there is not a chemist, not an engineer, worthy of the name, who would not prefer efficient, honorable public service, freed from party politics, to a mere money-making job.

### Government by Engineers or by Lawyer-Politicians?

But most governments of the world have been run for so long almost exclusively by lawyer-politicians, that we have come to consider this as an unavoidable evil, until sometimes a large experiment of government by engineers, like the Panama Canal, opens our eyes to the fact that, after all, successful government is—first and last—a matter of efficiency, according to the principles of applied science.

Was it not one of our very earliest American chemists, Benjamin Thompson, of Massachusetts, later knighted in Europe as Count Rumford, who put in shape the rather entangled administration of Bavaria by introducing scientific methods of government?

Pasteur was right when one day exasperated by the politicians who were running his beloved France to ruin, he exclaimed:

"In our century science is the soul of prosperity of nations and the living source of all progress. Undoubtedly the tiring daily discussions of politics seem to be our guide. Empty appearances! What really leads us forward are a few scientific discoveries and their applications."

---

The British Guiana gold industry has experienced a revival in the last two years, according to a consular report by Lester W. Collins. The recovery is mainly by dredging and hydraulicking. Lode mining has been disappointing. In spite of the crude methods employed, the output for 1913 was 51,765 oz.

# Cyanide Practice in the Porcupine District, Ontario, Canada—I.

BY H. C. PARMELEE

### General

About 100 miles northwest of Cobalt in northern Ontario lies the gold-mining district of Porcupine. A slight divide between the Cobalt and Porcupine districts separates the St. Lawrence and Hudson Bay watersheds, Porcupine being on the northerly or Hudson Bay slope. Gold mining has attracted attention to the Porcupine area for the last four or five years, following the spectacular discovery on what is now the Dome property. In 1911 the district was ravaged by a succession of forest fires which destroyed the mine and mill buildings of the Hollinger, Dome and other companies, and wiped out the town of South Porcupine; but despite these obstacles the district is now in a prosperous condition and is beginning to make a substantial gold production.

According to statistics compiled by Mr. A. A. Cole, mining engineer for the Temiskaming & Northern Ontario Railway Commission, the gold production of the Porcupine district in 1913 was valued at $4,284,928, which nearly equals the entire previous production of Ontario. The output of gold for 1913 increased 147 per cent over that of 1912, and constituted 29 per cent of the gold production of Canada and 95 per cent of that of Ontario.

FIG. 1—HOLLINGER MILL, TIMMINS, PORCUPINE DISTRICT

In marked contrast to the complex silver ores of Cobalt, those of Porcupine consist mainly of free gold in quartz and schist, accompanied by varying small quantities of sulphide minerals, principally pyrite. Metallurgy at Porcupine is accordingly much simpler than at Cobalt, and a high recovery is easily made by amalgamation and cyanidation. Nevertheless milling practice in the Porcupine district is diverse, and of the four principal mills each differs decidedly from the others in equipment and method of operation.

### The Hollinger Mill

The largest and most important producing company in the Porcupine district is the Hollinger Gold Mines, Ltd. The first mill erected by the company was destroyed by fire in May, 1911, and was immediately replaced by the present plant, which commenced operating in June, 1912, and has been in successful operation since that time. The milling record for 1913 shows a total of 140,131 tons of ore treated, of which 138,291 tons was from the Hollinger mine, having an average value of $18.56 per ton. The extraction was 96.1 per cent, and the cost of milling was $1.63 per ton.

The process adopted at the Hollinger consists, briefly, in crushing and grinding the ore in cyanide solution by means of stamps and tube mills, concentrating, and separately cyaniding the concentrate and tailing. The concentrate is finely washed and dewatered in a Door three-deck washing classifier, and the tailing is treated by continuous decantation and vacuum filtration. The Merrill system of zinc-dust precipitation is used, and the precipitate is smelted and refined.

### Nature and Value of the Ore

As delivered to the mill, Hollinger ore is composed of about one-fourth quartz and three-fourths schist, the latter being quite heavily mineralized with pyrite which constitutes about 5 per cent of the mill feed. Gold occurs throughout the ore in the free state and is very finely divided. It is accompanied also by some silver, the native metal having a gold fineness of 825 and a silver fineness of 125. The gross value of the ore now being treated is between $13 and $14 per ton, which is less than the average value for 1913, due to the development of large lower-grade ore bodies in the mine.

The ore is raised from the mine in 3-ton skips and delivered to the coarse-breaking plant where it is crushed successively through No. 7½ and No. 5 gyratories. A trommel screen with 2½-in. openings intervenes between the two crushers and removes the undersize from the discharge of the first gyratory. An extra man is employed on the second crusher to remove wood and steel from the ore. He takes out about 1 cu. ft. of wood per hour and more or less steel, thus reducing the possibility of breakage at the crusher and improving the mill work generally. The expense of $2.25 per day is fully justified by the results obtained.

The crushed ore is conveyed to the top of the mill by an inclined belt conveyor, 350 ft. long. The inclination is 12 deg. and the rate of travel is 250 ft. per minute. This belt has been in service for two years and has an anticipated life of two and a half years. A Merrick automatic weigher is to be installed on the belt to give an accurate record of ore delivered to the mill. A further change under consideration is to screen the ore before delivery to the battery bins, and install additional tube mills to grind the fine portion.

The battery bins have a capacity of 1000 tons. They are flat-bottomed, and the ore is discharged to the batteries through side gates. This arrangement necessitates occasional shoveling when ore is low in the bins, and it is likely that a change will be made, substituting central hoppers for the flat bottom. In that event the batteries will be equipped with belt feeders operated by Hooper attachments to the tappets.

At present the crushing equipment consists of forty 1500-lb. stamps, but the mill capacity is being increased by the addition of twenty more. They drop 6¼ in., 108 times a minute, being run rapidly in order to secure a good splash in the mortars. The height of discharge is 2 in. The screens have oblong openings—four meshes per inch in one direction and three in the other. The wires forming the warp are of lighter weight than the shoot wires, giving a screen that does not blind as easily as one in which all wires are of the same weight.

### Maple-Cog Bevel-Gears on Stamp Drive

The stamps are grouped in batteries of ten, with separate 6½-in. cam shafts for each set of five stamps. A 100-hp motor provides the power ten stamps and one tube mill, a countershaft for the batteries being driven from the tube mill shaft by maple-cog bevel-gears. The substitution of maple-cog gears for steel has effected a great saving in cost. Steel gears cost $105 per set and lasted five months, whereas a set of maple cogs costs but $25 and lasts six months. Moreover, the maple-cog gears are practically silent in operation, while the steel gears were very noisy. The motors have Reynolds silent-chain drives, but these will be replaced by Wuest gears, which are expected to prove more satisfactory in transmission of power.

### Stamping in Cyanide Solution

The ore is crushed in cyanide solution added at the batteries at the rate of 3 tons per ton of ore. Under the conditions prescribed the batteries are showing an actual duty of 15 tons per stamp, being in operation 95 per cent of the possible running time. The battery discharge flows to the tube mill-classifier circuit for fine grinding, one tube mill and one Dorr duplex classifier receiving the product from ten stamps. The ratio of stamps to tube mills, 10 to 1, is the same as adopted at the Nipissing mill in Cobalt and is also in accord with the latest South African practice. The ratio of solution to ore, however, 3 to 1, may be considered low. The classifiers are 24 ft. long, being 8 ft. longer than standard machines, and are set at a pitch of 2⅝ in. per foot, thus securing gravity flow to and from tube mills.

Experiment is being made with the Globe tube mill liner, which is a sectional chilled-iron liner resembling the El Oro except that the ribs extend around the inner surface of the tube instead of lengthwise, the space between ribs tapering counter to the travel of the mill. Pebbles become firmly wedged in the space between the ribs and relieve the metal from most of the wear. While the Globe liner has not been in use long enough to determine its life, from present indications it is expected to last more than a year and reduce the cost of tube milling. At present a silex lining 5 in. thick costs $450 in place and lasts about seven months. The time lost in lining with silex is sixty hours. The Globe lining, on the other hand, costs $750 in place, but it probably will last longer than silex, and the time lost in replacing it is only eighteen hours.

Danish and French pebbles are used, at a cost of $20 and $18 per ton, respectively. The consumption of either kind is 4½ lb. per ton of ore treated.

From 75 per cent to 80 per cent of the ore is ground to minus 200-mesh in order to insure liberation and rapid dissolution of the gold. In Table I is given a screen analysis and assay value of the battery and tube mill discharges and both products of the Dorr classifier. A marked concentration will be noted in the tube mill-classifier circuit.

Table I.

| Screen analysis .. | +8 | +20 | +40 | +100 | +150 | +200 | −200 | |
|---|---|---|---|---|---|---|---|---|
| Battery discharge | 17.1 | 31.3 | 14.6 | 17.0 | 3.5 | 1.0 | 15.5 | |
| Tube mill discharge | 0.5 | 0.9 | 1.6 | 41.4 | 15.0 | 5.0 | 35.6 | |
| Classifier sand ... | 9.9 | 12.1 | 7.4 | 42.9 | 15.3 | 4.3 | 8.1 | |
| Classifier slime .. | ... | . | 0.2 | 5.6 | 11.0 | 4.4 | 78.8 | |
| Value per Ton | | | | | | | | Average |
| Battery discharge . | $20.40 | $9.20 | $7.60 | $28.40 | $26.50 | $31.20 | $17.20 | $16.17 |
| Tube mill discharge | 23.40 | 27.20 | 366.00 | 183.60 | 156.20 | 136.60 | 121.60 | 155.81 |
| Classifier sand . | 29.30 | 107.20 | 171.80 | 248.40 | 273.60 | 204.36 | 555.00 | 231.02 |
| Classifier slime ... | . .. | .... | 18.20 | 13.10 | 2.50 | 3.70 | 1.50 | 4.80 |

### Rapid Dissolution of Gold in Tube Mills

About 70 per cent of the gold in the ore goes into solution in the tube mills, where cyanide is added to bring the solution up to a strength of 1.3 lb. KCN. A further 26 per cent is dissolved in the subsequent milling operations. Table II shows the distribution of the gold value in a ton of ore at the successive stages of the process, and the progressively diminishing value of the ore from beginning to end of treatment. Table concentrate is cyanided separately from the balance of the ore, and at the time of making the tests on which this table is based, treated concentrate was being returned to the table tailing and receiving the regular cyanide treatment. The item of $0.22 in the table represents this latter part of the concentrate.

Table II.
*Gold Distribution per Ton of Ore*

| | Contained in Concentrate | | Contained in Non-concentrate | | Total | | |
|---|---|---|---|---|---|---|---|
| Treatment | Head | Tailing | Head | Tailing | Head | Tailing | Per Cent Recovery |
| Tube milling. | $10.92 | $3.00 | $2.20 | $0.60 | $13.12 | $3.60 | 72.6 |
| Concentration | 3.00 | 0.82 + 0.22 | 0.60 | 0.55 | 3.60 | 1.59 | 15.3 |
| Decantation.. | 1.04 | 0.10 + 0.22 | 0.55 | 0.45 | 1.59 | 0.77 | 6.2 |
| Filtration.... | 0.32 | 0.19 | 0.45 | 0.33 | 0.77 | 0.52 | 1.9 |

### Removal of Wood Pulp at Classifiers

Although a great deal of wood is removed from the ore at the crushers, small pieces find their way to the stamps and are crushed to a coarse pulp. This accumulates in the Dorr classifiers and is removed in a novel manner. As the slime leaves the classifier it flows onto a horizontal screen which retains the small pieces of wood, and these are removed from the screen by a reciprocating brush connected to the classifier mechanism. On the forward stroke of the rakes the brush travels clear of the screen, but is in contact with it on the backward stroke.

A mine-car full of this wood pulp is thus collected every day. It has a value of about $2 per ton. It is burned, and the ash, which has a value of $50 per ton, is added to the concentrate and cyanided. An interesting fact observed in connection with the wood pulp is that only sulphide minerals adhere to it and give it its value. As the wood is of the resinous variety and odorous of the characteristic oils of pine and spruce, it is possible that we have here conditions favorable to the selection of sulphide particles from the slime pulp, according to the principles underlying the process of oil-flotation.

### Changes in Flow-Sheet

Reference is here made to the flow-sheets outlined in Figs. 2 and 3, showing certain important changes that recently have been made in the treatment. Fig. 2 gives the general outline of the method in use prior to June, 1914, and Fig. 3 embodies the subsequent changes which will be mentioned in greater detail later. The main points of difference in the method now adopted are (1) the substitution of primary Dorr thickeners for the dewatering boxes ahead of concentration; (2) the precipitation of solution overflowing these primary thickeners, and (3) the separate treatment of concentrate and tailing.

Another change in operation that has resulted in substantial economy is in the solution circuit. Formerly all of the mill solution was pumped to storage tanks at the top of the mill and then piped back to various points of application. Also, dependence was placed entirely on the shiftmen to regulate the flow of solution. According to the rearranged circuit only a part of the solution is pumped to the head of the mill, and the flow is governed by automatic floats in storage tanks. The change has greatly diminished the power consumed in pumping and has reduced the number of pumps formerly required. The tabulation below gives some comparative data on the two methods of operation.

| | Foot-tons Solution Pumped, 24 Hours | Foot tons Solution Pumped per Ton Ore | Theoretical HP. Required |
|---|---|---|---|
| Former system ..... | 276,480 | 576 | 11.61 |
| Present system...... | 150,840 | 311 | 6.28 |

### Separate Treatment of Mineral and Gangue

A feature of Hollinger practice that is not adopted in the other mills of the district is concentration, with separate cyanidation of concentrate and tailing. The reasons for this will be mentioned later.

Slime from the Dorr classifiers is distributed to ten primary Dorr thickeners, 13 ft. by 6 ft., which dewater the pulp for concentration. The overflow carries off the lighter solids, amounting to about one-quarter of the tonnage, which goes to a 30-ft. by 10-ft. Dorr thickener, the overflow from which passes through Merrill clarifying presses and thence to precipitation. The underflow from this large thickener is added to the table tailing.

The thickened underflow from the primary thickeners contains about 50 per cent solution, but is diluted to 66 2/3 per cent by addition of solution from the second step of continuous decantation before distribution to the Deister concentrating tables. The wash water used in concentration is overflow solution from the thickeners in the second step of continuous decantation. It is applied at the rate of one ton for each ton of solids concentrated. The table tailing thus diluted is pumped to the first step of continuous decantation, while the concentrate is treated separately. Lime is not added to the ore until after concentration.

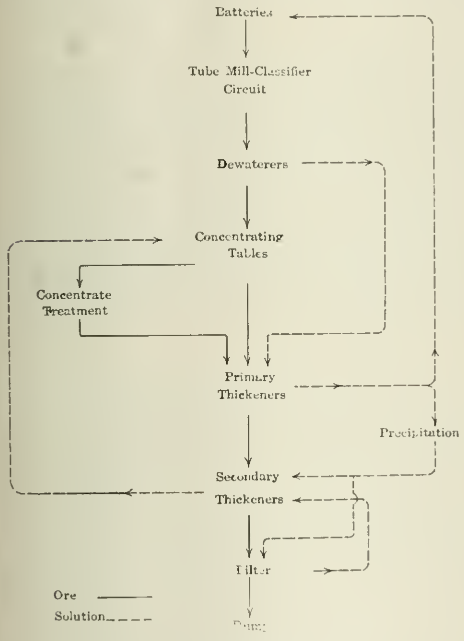


FIG. 2—DIAGRAM OF FORMER METHOD OF TREATMENT, HOLLINGER MILL

## Cyaniding Concentrate

One of the important changes recently made in the mill practice is in the treatment of concentrate. Formerly this product was reground and treated by pan amalgamation, after which the pulp was again combined with the tailing from concentration and put through the cyanide process as outlined in Fig. 2. Recovery by amalgamation proved to be almost nothing and this step was abandoned. Further, the cyanide extraction on concentrate was not as complete as on tailing; and yet after the two had been combined it was impossible either to give the concentrate a special treatment or recover it separately from the tailing for further treatment. Consequently the system was changed as indicated in Fig. 3, and concentrate is now kept entirely separate from tailing. An incidental benefit of this change was an improvement in the work of the thickeners and filters, where the heavy sulphides formerly caused trouble.

The value of the concentrate is about $70 per ton. It is agitated for eight hours in 10-lb. cyanide solution, after which it is washed free from dissolved gold by passing through a Dorr three-deck washing classifier. The residue still has a value of about $6 per ton, but it is impossible to get a further extraction by cyaniding. Experiments indicate that by roasting and then cyaniding an additional extraction can be made and the residue reduced to a value of $1 per ton. Anticipating future treatment by this method, the concentrate residue is being stored.

No particular difficulty is experienced in cyaniding concentrate. No advantage is gained by regrinding, and the solution does not become foul when the concentrate is fresh. Chemical consumption per ton of concentrate treated is as follows: cyanide, 2 lb.; lime, 1 lb. Protective alkalinity is maintained at 1 lb. per ton.

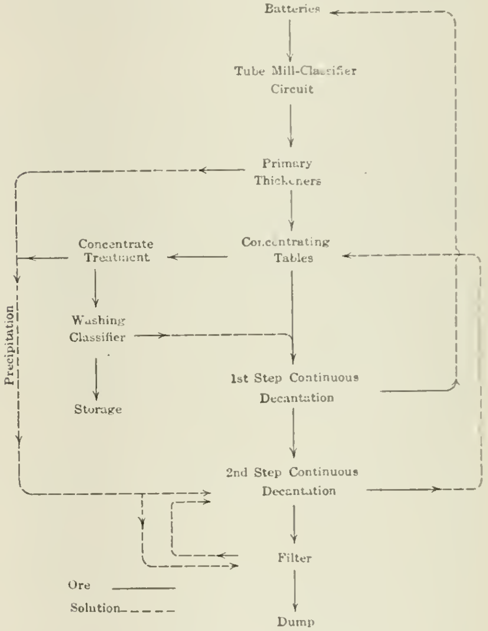


FIG. 3—DIAGRAM OF PRESENT METHOD OF TREATMENT, HOLLINGER MILL

Agitation is performed by mechanically stirring a pulp of 40 per cent solids and 60 per cent solution in Wheeler grinding pans. Aeration and thorough mixing are aided by pockets riveted to the periphery, opening in the opposite direction to the travel of the stirrers. These pockets have the effect of preventing the continuous swirl of the pulp by breaking the waves formed by the stirrers and producing counter currents. The device is very successful and well adapted to use with mechanical stirrers.

## Continuous Decantation of Slime Tailing

Although a Moore vacuum filter is used for final dewatering and washing of slime, continuous decantation is relied upon for the displacement of most of the dissolved gold before the pulp is filtered. As an example of the tremendous change brought about by the adoption of the decantation process, it may be stated that before it was introduced the filters were daily receiving solution valued at about $7,000, whereas after continuous decantation was adopted only $600 in dissolved gold was sent daily to the filters. This illustrates the value of continuous decantation, even in those cases where a filter is used as a final slime dewaterer.

The equipment for continuous decantation consists of four 30-ft. by 15-ft. Dorr thickeners in the first step, and four 30-ft. by 12-ft. in the second step. The first four thickeners receive the diluted table tailing, combined with wash solution from the concentrate-dewatering classifier. The overflowing solution runs by gravity back to the batteries. The thickened underflow is transferred to the second set of four thickeners and there diluted with barren solution from the precipitation presses and wash solution from the filters. The overflow from the second set of thickeners is used as wash water on the concentrating tables and the thickened underflow is filtered.

### Overload Indicator for Thickeners

All of the Dorr thickeners used in continuous decantation are run at the rate of one revolution in five minutes. Power consumption is about $\frac{1}{8}$ hp for each thickener. Unless these machines are provided with some sort of overload alarm or indicator, thick pulp may be allowed to accumulate abnormally in the bottom of the tank due to variations in amount of feed. The condition may be corrected, of course, by changing the espigot in the discharge pipe, or, where diaphragm pumps are used, increasing their speed or lengthening their stroke. But if the attendant has no warning of the increasing density of the pulp in the bottom of the tank, the vertical shaft may be twisted or the rakes broken before he can relieve the condition by increasing the underflow. Hence the value of an alarm or indicator.

The manufacturers of the Dorr thickener supply an electric overload alarm, in which the increasing resistance of the pulp on the rakes finally causes an electrical contact to be made by the thrust of the driving shaft against a steel spring. The contact rings a bell and indicates on an annunciator the particular thickener involved. An automatic pressure record is also made at the thickener by a pointer that is deflected across a dial by the thrust of the driving shaft. A pencil carried on the end of the pointer registers the maximum pressure on a card placed in the dial.

The indicator adopted by Mr. Cunningham, superintendent of the Hollinger mill, works on a similar principle but has no electrical connections. The thrust of the driving shaft against a light spring is communicated to a pointer that moves across a dial marked with a scale indicating the hp consumed in driving the rakes. The end of the pointer carries a knife-edge extending through a piece of tracing cloth mounted on the dial. As the required power increases, the knife cuts a longer slit through the cloth and thus records the maximum power used at any time during a shift.

As stated before, the power normally required in operating a thickener is about $\frac{1}{8}$ hp. One and two-thirds horse-power will twist the vertical shaft at one-fifth r.p.m. Hence it is desirable that the power applied through the shaft shall not exceed 1/3 hp; and the shiftman is supposed to see that this figure is not exceeded and preferably not reached. The first duty of the attendant coming on shift is to inspect the indicators and report instances of excessive power as indicated by the slit in the tracing cloth. Prompt attention to this duty relieves him of responsibility for the negligence of the shiftman preceding him, while failure to make an immediate inspection and report makes it impossible to throw the blame on his predecessor and leaves him liable for the improper operation of the thickener. This system has resulted in careful attention to the work. The value of the indicators is shown by the fact that no breakage has occurred on those thickeners that are equipped with them, while several instances of damage occurred where they were not installed.

### Vacuum Filtration

The underflow from the last thickeners in the continuous decantation system contains about 35 per cent moisture. It is drawn from the tanks by diaphragm pumps and discharged to the loading tanks of the Moore filter. The pumps are run from $2\frac{1}{2}$-in. eccentrics at a rate of 30 strokes per minute, the eccentric motion being transmitted to the diaphragm by bell cranks. The length of stroke of the diaphragm may be regulated while the pump is running, and is variable between zero and 4 in.

The Moore vacuum filter is arranged in two units, each consisting of two 56-leaf baskets and three tanks for loading, washing and discharging, respectively. A common acid tank serves both units. The baskets are handled by an electric crane of 30 ft. span and have an aggregate filter surface of about 19,000 sq. ft.

The filter leaves are constructed of $\frac{3}{4}$-in. pipe covered with 8-oz. duck. There are two thicknesses of duck about the pipe, four at the corners of the leaf and six at the outside seams. Thus constructed the leaves last 18 months. They are made at the mill at a cost of $12.50 each, of which $7 is for material other than pipe, $3.50 for labor, $1 for assembling and $1 for header and pipe.

Acid treatment is given every five weeks with a 1 per cent commercial hydrochloric acid solution. After three weeks' use of a fresh leaf, however, it is noted that the displacement of gold solution is less efficient and the value of the residue begins to rise. It is likely that acid treatment every three weeks would give better metallurgical results and be more profitable.

A complete cycle of filtration requires 15 minutes for loading, 50 minutes for displacement with barren solution and 15 to 20 minutes for washing with water. A load of 20 tons can be accumulated in 10 minutes, but 15 minutes is the average maintained over long periods of time. The washed cake is discharged with 25 per cent moisture. It has a gross value of $0.55 per ton, the loss in dissolved gold and silver being $0.05 per ton.

The slime in the loading tanks is kept in suspension by agitating with air-lifts, one of which is placed in the center of each hopper. The lift-pipe is 6 in. in diameter and extends to within 6 in. of the bottom of the hopper. A $\frac{3}{4}$-in. air-pipe extends to within 4 in. of the bottom of the lift-pipe, being suspended loosely and connected by hose with a source of compressed air. As the air-pipe opens downward it does not become clogged with slime. Other means of keeping the slime in suspension in these tanks have proved inadequate, but the present method is successful.

### Zinc-Dust Precipitation

Pregnant solution from the overflow of the primary thickeners (Fig. 3) is first partly clarified in a Dorr thickener, as already explained, and finally in two 20-leaf, 36-in. Merrill clarifying presses. These are sluiced three times a shift with a solution at 70 lb. pressure, and acid-treated every three weeks, 800 lb. commercial hydrochloric acid being neutralized in the latter operation. The equipment for precipitation consists of a zinc-dust feeder, three 20-leaf, 52-in. Merrill presses and the necessary complement of pumping apparatus.

The value of pregnant solution is about $5 per ton. The precipitation ratio—tons of solution precipitated per ton of ore—is 2.67, which is low considering the grade of ore treated. Zinc consumption is 0.6 lb. per ton of ore. Chemical consumption of cyanide is 0.2 lb. and mechanical loss 0.25 lb., giving a total of 0.45 lb. per ton of ore. Lime consumption is 2.5 lb. per ton of ore treated.

### Precipitate Smelted in Blast Furnace

Precipitate from the presses is dumped into hoppers underneath, and taken thence by cars to the refinery. Here a smelting mixture is made, thoroughly mixed and allowed to "set," after which it is cut into bricks and smelted in a small blast furnace with 1½ tons of coke per ton of charge. The smelting mixture consists of 100 parts precipitate, 135 litharge, 15 borax, 5 soda ash, 4 sand and some flue dust.

Since the precipitate receives no preliminary acid treatment, the furnace slags have a high zinc content. The precipitate has a value of about $40 per pound and contains 54 per cent zinc and 5 per cent lead, the latter being derived from the lead acetate used in concentrate treatment and from the zinc dust which contains about 2 per cent lead. The slag formed in the first smelt is retreated in the furnace, after which it is sent to the mill and cyanided, an extraction of 60 per cent being made. Flue dust is formed at the rate of 60 lb. per ton of precipitate charge, or about 200 lb. monthly. The following tabulation gives the value of the various products and an average analysis for zinc and lead.

| Product | Gold and Silver, Value per Lb. | Zinc, Per Cent | Lead, Per Cent |
|---|---|---|---|
| Precipitate | $40.00 | 54 | 5 |
| First slag | 0.04 | 35 | 5 |
| Second slag | 0.02 | 28 | 4 |
| Flue dust | 0.50 | 30 | 70 |

The base bullion is cupelled in an English cupel furnace. A cupel mixture that has proved very satisfactory, giving cupels that last for three runs, has the following composition: 100 parts fireclay, 150 cement, and 200 of screened limestone—10 + 60 mesh in size. The cupelled bullion is finally melted and refined in a Monarch oil-fired furnace and cast into bars. The resulting bullion has a total fineness of 960, of which 830 is gold and 130 silver. It contains also about 3 per cent copper and some lead and zinc.

### Cost of Milling

The cost of milling operations for the year 1913 was $1.628 per ton, but this figure is abnormally high owing to irregular and inefficient operation during the early months of the year when there were serious labor disturbances in the district. Current milling cost will vary from $1.10 to $1.15 per ton, and is fairly represented in the distribution given below which is based on the treatment of approximately 15,200 tons of ore during the four-week period ending May 20, 1914. The mill was in operation 94 per cent of the possible running time. The gross value of the ore treated was $12.93 per ton, and the extraction was 95.7 per cent.

### Distribution of Cost

| Account | Per Ton |
|---|---|
| General milling charges | $0.045 |
| Superintendence | .049 |
| Tailing disposal | .017 |
| Heating | .027 |
| Lighting | .006 |
| Shoveling in bins | .004 |
| Assaying | .013 |
| Coarse crushing | .073 |
| Conveying (including amortization of belt) | .033 |
| Stamping | .137 |
| Classifying and tube milling (including 2 new liners) | .196 |
| Concentrating | .050 |
| Handling concentrate | .012 |
| Treating concentrate | .031 |
| Handling pulp | .033 |
| Thickening | .014 |
| Continuous decantation | .036 |
| Filtration | .081 |
| Neutralizing | .018 |
| Clarifying and precipitating | .057 |
| Smelting and refining | .058 |
| Pumping solutions | .022 |
| Cyanide | .074 |
| Cleaning mill | .028 |
| Alterations | .031 |
| Total | $1.145 |

The total working cost for the period above mentioned, including mining, milling, taxes, insurance, employees' loyal service bonus, etc., was $4.219 per ton.

We are indebted to Mr. Noel Cunningham, superintendent of the Hollinger mill for his courtesy in supplying many details and data of operation published in this article.

---

## A New Theory of the Ammonia Soda Process

BY WILLIAM MASON

The ammonical sodium chloride solution of the ammonia soda process, as carried on at present by the Solvay system, is carbonated in two stages. In the first stage it is treated with carbonic acid until about 80 per cent of the ammonia is carbonated to ammonium carbonate. In the second stage this solution if further treated with carbonic acid and sometime before the whole of the ammonia is converted into ammonium carbonate a precipitate is formed which the author finds is sodium carbonate, and is of opinion that when the whole of the ammonia becomes carbonated a reaction takes place according to the following equation:

$$(NH_4)_2CO_3 + 2NaCl = Na_2CO_3 + 2NH_4Cl.$$

Some of the sodium carbonate is precipitated in such a concentrated solution, while the remainder remains in solution and is precipitated out as sodium bicarbonate in the second stage of carbonation. In Table I are given the results of the working from a Solvay tower which clearly show that this is so, as regularly as from a solution of sodium carbonate.

TABLE I

| Height in Meters | Alkalinity cc n/10 acid to neutralize 10 cc of liquor | Temperature °C | Sodium Chloride grams per 100 cc |
|---|---|---|---|
| 18 | 41.4 | 39.6 | 24.37 |
| 17 | 40.3 | 42.3 | 23.55 |
| 16 | 38.5 | 43.7 | 22.22 |
| 15 | 35.8 | 45.0 | 20.88 |
| 14 | 33.7 | 48.0 | 19.57 |
| 13 | 31.2 | 47.5 | 18.40 |
| 12 | 28.5 | 47.5 | 17.30 |
| 11 | 26.6 | 47.3 | 16.25 |
| 10 | 24.4 | 47.0 | 15.30 |
| 9 | 22.8 | 47.0 | 14.25 |
| 8 | 21.0 | 46.2 | 13.16 |
| 7 | 19.1 | 44.2 | 12.26 |
| 6 | 17.3 | 43.0 | 11.36 |
| 5 | 15.9 | 41.5 | 10.54 |
| 4 | 15.0 | 38.0 | 9.78 |
| 3 | 13.4 | 34.0 | 9.10 |
| 2 | 12.2 | 32.0 | 8.46 |
| 1 | 11.2 | 32.0 | 8.46 |

When the precipitate begins to form, analysis shows that 50 per cent of the sodium chloride has already been decomposed and that there is 11.87 per cent of sodium carbonate in solution. A solution from the center of a Solvay tower contains about 5.83 per cent of sodium carbonate. The mother-liquor, after the separation of the sodium bicarbonate, contains only 0.53 per cent of the same. The following is an analysis of this liquor; grams per 100 c.c.

| | |
|---|---|
| Ammonium carbonate | 8.13 per cent |
| Sodium carbonate | 0.53 per cent |
| Ammonium chloride | 18.13 per cent |
| Sodium chloride | 8.46 per cent |

Analyses of the sodium bicarbonate produced by the Solvay system show that it also contains sodium carbonate:

| | |
|---|---|
| Sodium bicarbonate | 71.3 per cent |
| Sodium carbonate | 4.0 per cent |
| Sodium chloride | 0.2 per cent |
| Ammonia | 0.5 per cent |
| Moisture | 24.0 per cent |
| | 100.0 |

The theory of this process, usually given in text books, is that the ammonia first becomes bicarbonate and then decomposed the sodium chloride, sodium bicarbonate being precipitated. But if that was so the ammonium bicarbonate, being equally as insoluble as sodium bicarbonate, would be also precipitated. Besides much heat is absorbed in the reaction of ammonium bicarbonate with sodium chloride; whereas it is well known in practice that in the Solvay tower much heat is evolved, because the precipitation of sodium bicarbonate by carbonic acid from a solution of sodium carbonate is exothermic.

When this process was first introduced by Messrs. Dgar and Hemming it was stated that: To a concentrated solution of sodium chloride was added an equivalent quantity of ammonium sesquicarbonate in order to decompose it, and a current of carbonic acid gas passed through the mixture to saturate the ammonia to make decomposition as perfect as possible, and even an earlier worker, John Thom of Camlachie, Scotland, was said to have mixed the sodium chloride with ammonium sesquicarbonate in the dry, added water and then pressed the mixture.

Now it is well known that when ammonium sesquicarbonate is dissolved in water it is resolved into the neutral carbonate and the bicarbonate, and what happened in these early operations was that ammonium bicarbonate so formed decomposed the sodium chloride, sodium bicarbonate being precipitated, and even when further quantity of carbonic acid was added, it was found that only two-thirds of the sodium chloride has been decomposed. In the Schloesing method, where solid ammonium bicarbonate is treated with a solution of sodium chloride, only two-thirds of the sodium chloride are decomposed, and the same rate of decomposition is also found in the Solvay system.

The opinion of the author is that it is the effect of the ammonium chloride which decides the quantity of sodium chloride decomposed by weakening the action of the ammonium carbonate on the sodium chloride, for when the ammonium chloride is separated from the mother-liquor of the carbonating process and it is further treated with carbonic acid a much larger percentage of sodium chloride is decomposed.

Oxford, England.

---

**The metal production of Oregon in 1913** was valued at $1,746,402, an increase of more than 100 per cent over that of 1912. The Geological Survey states that copper was the only metal that did not show an increase in production. The gold yield was $1,627,710; silver, 179,036 fine oz.; copper, 43,330 lb.; lead, 87,207 lb.

**The quicksilver industry** showed decreased activity in 1913, according to figures compiled by the U. S. Geological Survey. With the exception of the production in 1908, that of 1913 was the lowest since 1860. The decline was due largely to increased foreign production, a dull market and lower prices. California was the largest producer, with 15,591 flasks of 75 lb. out of a total domestic production of 20,213 flasks. The rapid extension of the cyanide process for recovering gold and silver has materially affected the use of quicksilver for metallurgical purposes.

**The specific heat of copper** in the interval 0 deg. to 50 deg. C., with a note on vacuum-jacketed calorimeters, is the subject of a bulletin published by the U. S. Bureau of Standards. The bulletin was written by Mr. D. R. Harper, 3d. The determinations in the temperature range 0 deg. to 100 deg. are interpreted to indicate that the specific heat of copper (hard-drawn probably excepted) at 50 deg. is between 0.0926 and 0.0931.

---

# Refractometry

BY G. A. SHOOK

## I.—Fundamental Principles

*Refraction.*—Whenever a beam of monochromatic light passes from one medium, such as air, into another medium of a different *optical density*, such as glass, the beam will be bent out of its path. If the second medium has a greater optical density than the first the beam will be bent *toward the normal*, while if it is less dense it will be bent *away* from the normal to the interface, as shown in Fig. 1.

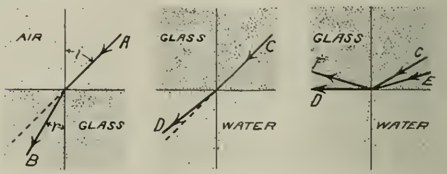


FIG. 1—REFRACTION

The amount of bending or *refracting* is slightly different for different substances. Practically all solids and liquids are optically denser than air and a few gases are optically rarer but there is no simple relation between optical density and mass density. The relation between the incident angle $i$ and the refracting angle $r$ is given by the simple formula

$$n = \frac{\sin i}{\sin r}$$

The constant $n$ is known as the *refractive index* and it is an important optical constant of liquids and solids. When light passes from a vacuum into any medium the ratio $\sin i/\sin r$ is called the *absolute index* of refraction, and when it passes from one medium into another, as from air to glass, it is called the *relative index*. Unless otherwise stated it is always understood that the angle of incidence is measured in air, that is, the word "relative" is usually omitted.

The index of refraction may also be defined in terms of the velocity of light in two different media. Thus, if we represent the velocity of light by $V$ the relative index for any substance, say glass, may be expressed by the relation

$$n_g \text{ (referred to air)} = \frac{V \text{ (in air)}}{V \text{ (in glass)}}$$

For the absolute index of air we have

$$n_a \text{ (referred to vacuum)} = \frac{V \text{ (in vacuo)}}{V \text{ (in air)}}$$

Whence the absolute index for glass is

$$n_g \text{ (referred to vacuum)} = \frac{V \text{ (in vacuo)}}{V \text{ (in glass)}}$$

$$= n_g \text{ (referred to air)} \times n_a \text{ (referred to vacuum)}$$

or

$$n_g \text{ (absolute)} = n_g \text{ (relative)} \times n_a$$

Hence if we know the index for air at the desired

TABLE I—REFRACTIVE INDICES

| Substance | °C | $n_d$ |
|---|---|---|
| Fluorspar | 18 | 1.4339 |
| Iceland spar | 18 | 1.6584 |
| Water | 20 | 1.33299 |
| Water | 30 | 1.33248 |
| Carbon bisulphide | 20 | 1.6277 |
| Ethyl alcohol (absolute) | 25 | 1.35941 |
| Ethyl alcohol (5% $H_2O$) | 25 | 1.36125 |
| Diamond | | 2.4699 |
| Cotton-seed oil | 15 | 1.4743 |
| Sesame oil | 15 | 1.4748 |
| Almond oil | 60 | 1.4555 |

temperature the absolute index of any substance may always be determined from its relative index. The refractive indices of a few common substances are given in Table I.

If the light in Fig. 1 were transmitted in the reverse direction *BA* instead of the direction *AB* it would follow the same path. The same is true for the path *CD*.

Now if the ray *C* is gradually oriented so that it makes a larger and larger angle with the normal, the ray *D* will likewise make with the normal a larger and larger angle and a position of *C* may be found such that the ray *D* passes along the interface as shown in the third diagram of Fig. 1.

The angle made by *C* and the normal in this case is called the *critical angle* of *incidence*. Moreover, if the light is transmitted at grazing incidents, i.e., if it passes in the direction *DC* then it will be bent into the glass as shown. The critical angle of water is about 48 deg., that of crown glass 42 deg., while that of diamond is only 24 deg.

If the incident ray makes a still larger angle, the ray *D* will be bent back into the first medium, as shown by the path *EF*.

When this condition obtains, no light is transmitted and the incident light is said to be *totally reflected*. The ray *EF* now obeys the ordinary law of reflection, i.e., the angle made by *F* and the normal is the same as the angle made by *E* and the normal.

It is not a simple matter to measure the angle of incidence and the angle of refraction directly with any accuracy, so that the index of refraction, *n*, is generally determined by some indirect method. When the substance can be formed into a prism with optically plane sides, which is seldom the case, then the refractive index may be determined in terms of the angle of the prism by means of an ordinary spectrometer.

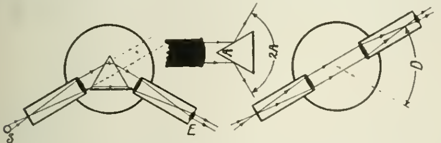


FIG. 2—SPECTROMETER METHOD OF DETERMINING THE INDEX OF REFRACTION

Light from a source of monochromatic radiation *S*, Fig. 2, such as a colorless gas flame in which some common salt is volatilized, falls upon the slit of the collimator and is rendered parallel by the collimator objective. This parallel beam is bent out of its path by means of a prism and thence passes through the telescope objective and forms an image of the slit. This image is finally observed by means of an eyepiece *E*.

To obtain the deviation angle one has only to set the cross-wires of the telescope on the image of the slit and to read the position of the telescope by means of the spectrometer circle when the beam is refracted by the prism and when the telescope is in line with the collimator.

The deviation, *D*, is always measured when the prism is set for *minimum deviation*; that is, when it is placed symmetrically with respect to both the incident and transmitted beams. If the prism were placed in any other position, then the deviation of the transmitted beam would be different for each position.

The position for minimum deviation is accurately obtained by adjusting the telescope and the prism so that the slit-image is in the field of view when the prism is approximately symmetrical to the collimator and to the telescope. It will now be found that upon rotating the prism slightly to the left the image passes to the left, stops, and returns to the right. This end-point, as it were, marks the position of *minimum deviation* and the cross-wires should then be set on the slit-image when the latter is in this position. This shift of the telescope, unless it is very slight, may necessitate a further small adjustment of the prism, and then again a slight movement of the telescope before the position is found such that on continuously rotating the prism to the left the image moves from the right just up to the cross-wires, stops, and returns again to the right.

The angle of the prism is obtained by setting it so that its base is approximately symmetrical with respect to the collimator as shown in Fig. 2, and then measuring the angle 2*A* by means of the telescope. The refractive index *n* in terms of the prism angle *A* and the deviation angle *D* is given by formula

$$n = \frac{\sin\left(\frac{A+D}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

This formula is only true when the prism is set for minimum deviation. To determine the refractive index of a liquid a hollow prism with plane parallel glass sides may be used, but there are other methods which are far more convenient.

The values of *n* thus determined depend only upon the color, or wave-length of the light used and they are always given for a particular color, generally yellow, the color of the sodium spectrum line. With a spectrometer of high resolving and dispersive power two sodium lines can be distinctly seen, and they are known as the *D* lines. The one that is the most refracted is designated $D_1$ and the other $D_2$. The wave-length of $D_1$ is 0.0000589 cm. and that of $D_2$ 0.00005896 cm. In refractometric measurements the mean of these two wave-lengths is variously written 5893A (Angström units), 0.5893μ (microns) and 0.00005893 cm.

In all cases it is necessary to specify for what wave-length the refractive index is determined and this may be done in any of the above ways. The variation of *n* with wave-length in the case of flint glass and carbon bisulphide is shown in Table III.

From Table I it is readily seen that the difference in *n* for different substances is so small that quite an accurate measurement is necessary in order to make the determination of this constant of any practical value in industrial work. While the spectrometer is used for absolute measurements it is not practical for industrial work since considerable care in manipulation is necessary in order to obtain accurate results and, moreover, to carry out a determination a large amount of the material to be tested is required.

Most of the instruments now in use utilize the phenomenon of total reflection. Some of these instruments are so constructed that white light may be used and a special illuminating device is therefore unnecessary, but with others monochromatic light must be used.

While it would be more logical to reduce all refractometric measurements to the refractive index, *n*, it is in some cases more convenient to give the refraction in terms of an arbitrary scale division. Most of the important instruments, however, that are provided with arbitrary scales are also provided with tables, so that the scale readings of a particular instrument can be converted into refractive indices.

In all work, therefore, it is very important to state the refraction in terms of the index and preferably for the *D* line. The user of any instrument provided with an arbitrary scale can readily transform refractive indices into scale divisions to suit his own work.

*Dispersion.*—If the ray of light *AB* incident on the interface, Fig. 1, is not monochromatic, i.e., not of a single color such as the yellow light emitted by a sodium flame then it will be spread out or *dispersed* in the second medium as shown in Fig. 3.

The blue rays are the most refrangible and the red the least.

The amount of spreading out and the extent to which all of the rays are refracted depends both upon the angle of incidence and the material of the medium. Thus for the same angle of incidence the refraction is different for water and for glass, but for the same material, say glass, the refraction is different for different angles of incidence.

When the slit of a spectrometer is illuminated by white light one sees, on looking through the telescope, a continuous succession of images of the slit; that is, the slit-image is drawn out into a band of color. Fraunhofer identified a large number of the most conspicuous absorption lines in the solar spectrum with the emission lines of familiar terrestrial elements and these are designated by the letters *A*, *B*, *C*, etc. The wave-lengths corresponding to a few of these lines are given in Table II

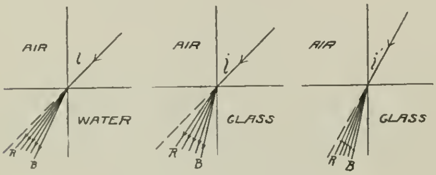


FIG. 3—DISPERSION

TABLE II—WAVE-LENGTHS OF THE FRAUNHOFER LINES

| | | | |
|---|---|---|---|
| A′ | 7677 A° | Red | K |
| A | 7605 | | |
| B | 6867 | | |
| C | 6563 | $H\alpha$ | Red |
| D | 5893 | Yellow | Na |
| E | 5270 | Green | |
| F | 4861 | $H\beta$ | Blue |
| G′ | 4341 | $H\gamma$ | " |
| h | 4103 | $H\delta$ | " |
| H | 3969 | | |
| K | 3934 | | |

In refractometry indices of refractions are generally referred to one of these lines. For the same wave-length interval the difference in angular deviation is by no means the same throughout the spectrum, but in general the shorter wave-lengths are separated the most. The difference between the refractive indices for any two wave-lengths or colors is called the *dispersion*. For a given substance the dispersion is different for different parts of the spectrum and for a given region of the spectrum the dispersion will be quite different for different substances. Thus for flint-glass the refractive index for the *C* line is 1.618 and that for the *D* line is 1.628, therefore the dispersion for the interval *D-C* is $n_d - n_c = 0.010$.

Since most of the visible spectrum is included between the *C* and *F* lines, the dispersion for this region, namely, $n_f - n_c$, is often taken as a characteristic constant of a solid or a liquid in the same way as we consider the refractive index for, say, the *D* line. This factor, $n_f - n_c$, is sometimes called the *mean dispersion* and sometimes the *medium dispersion*, while the interval $n_d - n_c$ or $n_f - n_g$, etc., is known as the *partial dispersion*.

Again, if the index of refraction is measured over any other range, say, from *A* to *H*, the dispersion $n_h - n_a$ is spoken of as the *medium dispersion*. Since the interval *C* to *F* comprises about all the visible spectrum, it is proportional to the dispersion of the entire visible spectrum, hence the notation *medi-dispersion*.

In general a substance which has a large $n_d$ will have a large medium dispersion, $n_f - n_c$, but this does not necessarily follow by any means. Let us consider, for example, the case of flint glass and carbon bisulphide. The indices for four lines are given in the following table:

TABLE III

| | Flint Glass | |
|---|---|---|
| C | 1.624 | 1.618 |
| D | 1.628 | 1.628 |
| F | 1.641 | 1.652 |
| H | 1.674 | 1.689 |

It is seen from this table that for the *D* line value of the index of refraction is the same in both cases, but the total dispersion for flint glass is 0.050 and for carbon bisulphide it is 0.071. Moreover, the partial dispersions for the two cases bear no simple relation to the complete dispersions.

The partial dispersions are, however, in each case greater for carbon bisulphide than for flint glass; that is, the large complete dispersion is accompanied with large partial dispersions, although there are even exceptions to this. In the case of carbon bisulphide and monobromonaphthaline the complete dispersion, *A* to *H*, for the latter is very much larger than for the former, while the partial dispersions *D* to *F* and *F* to *G′* are slightly less.

From the data on Jena glass, Table IV, it is seen that while the second substance has a slightly larger mean dispersion than the first its refraction for the *D* line is much less. Moreover, while the third substance has a higher mean dispersion than the second its index of refraction for the *D* line is larger than the second.

TABLE IV—JENA GLASS

| | $n_d$ | Mean Dispersion C to F |
|---|---|---|
| Medium phosphate crown | 1.5590 | 0.00835 |
| Silicate crown | 1.5109 | 0.00844 |
| Crown of high dispersion | 1.5149 | 0.00943 |

Manifestly one cannot infer that because the refraction for the *D* line is high the total dispersion will consequently be high, or conversely.

It is thus seen from the above examples that dispersion plays an important rôle. For instance, two substances under analysis may give the same value for $n_d$, but they may not show the same mean dispersion so that while a determination of $n_d$ would not tell us anything of the composition of a particular substance, a measurement of its dispersion might be of value.

*Index Refraction and Density.*—That the index of refraction varies considerably with the physical state of a substance has been known from the beginning of the history of light theories. The two most important changes are density and temperature. Laplace derived, from the emission theory of light, the expression

$$\frac{n^2 - 1}{d} = k = \text{const.}$$

Considerably later Gladstone and Dale determined empirically the relation

$$\frac{n - 1}{d} = k' = \text{const.}$$

Finally a third formula

$$\frac{n^2 - 1}{d\,(n^2 + 2)} = k'' = \text{const.}$$

was deduced from Maxwell's magnetic theory of light by a number of physicists.

These formulæ have been tested by many experiments, but most of the data has been derived from liquids. The temperature correction for either of these formulæ is small and is generally neglected except in refined work. The last two equations are now more generally used than the first and the second is preferable because of its simplicity.

The constant $k$, $k'$ or $k''$ is sometimes called the *specific refractive power* and the product of the specific refractive power and the molecular weight of a substance is called the *molecular refractive power*.

In the case of an organic solution or an electrolyte the refractive index does not increase at the same rate as the concentration. This may be due to the fact that hydration generally takes place.

Moreover, when a salt is dissolved in water the change in volume per unit quantity of salt is different for different concentrations. Therefore, when the density changes due to a change in concentration the refraction may still be a linear function of the density while it bears no simple relation to the concentration. If the concentration is, however, a linear function of the density, which is sometimes the case for limited ranges of concentration, then the refraction will increase at the same rate as the concentration. The above equations will also hold true when a change of density is effected by a temperature change.

When a salt is dissolved in water, the relation between the specific refraction of the salt $k$, that of the water $k_w$, and that of the solution $k_s$ is given by the simple relation

$$kx + k_w\ (100 - x) = 100\ k_s$$

where $x$ is the per cent of concentration. Assuming that $k_w$ does not change when the salt is dissolved into it, the specific refraction $k$ may be determined from a measurement of the refractive index of the solution.

Moreover, the sum of the *atomic* refractions of the elements of a compound is equal to the *molecular* refraction of the compound and this relation may be expressed by the simple equation

$$R = xr + x'r' + x''r'' \quad . \ . \ . \ .$$

where $R$ is the molecular refraction, $r$ is the atomic refraction, and $x$ the number of atoms that enter into composition.

In Table V are given the molecular refractions of lithium chloride, sodium chloride, etc. This data was taken from the works of Baxter, Boylston and others on "The Refractive Powers of the Halogen Salts of Lithium, Iodine and Potassium in Aqueous Solutions." This work was carried out with a Pulfrich refractometer and by means of a *differential method* an accuracy of two units in the fifth decimal place was obtained. The values given in Table V are all for the same concentration.

TABLE V—MOLECULAR REFRACTIVE POWERS

| | cl | Br | I |
|---|---|---|---|
| Li | 8.75 | 12.29 | 19.00 |
| Na | 9.25 | 12.80 | 19.43 |
| K | 11.35 | 14.19 | 21.48 |

This additive law of the atomic refractions has been the subject of much discussion and it is apparently only approximately true. We may at least, however, get a rough estimate of the molecular or atomic refraction of a number of elements that could not be determined otherwise. An example may be worked out from the above data. Since the molecular refraction varies slightly for different concentrations it is logical to compare only values obtained for the same concentration.

The value of the atomic refraction of hydrogen obtained for the $D$ line is 1.03 and a recent value for the molecular refraction of hydrogen chloride is 8.53, therefore, the atomic refraction of chlorine is $8.53 - 1.03 = 7.50$.

We may now write

$$r\ (\text{Na}) + r\ (\text{Br}) = 12.80$$

and

$$r\ (\text{Na}) + r\ (\text{Cl}) = 9.25$$

whence

$$r\ (\text{Br}) - r\ (\text{Cl}) = 3.55$$

or

$$r\ (\text{Br}) = r\ (\text{Cl}) + 3.55 = 7.50 + 3.55 = 11.05$$

In a similar manner we obtain for iodine

$$r\ (\text{I}) = 17.68$$

We can also determine the atomic refraction of Li, Na, or K. For example, the molecular refraction of NaCl is 9.25, whence the atomic refraction of Na is $9.25 - 7.50 = 1.25$. We may, of course, determine the atomic refraction of Na from NaBr or NaI.

*Index of Refraction and Temperature.*—The relation between the refractive index and the temperature of a substance is practically linear and may be expressed by the formula

$$\frac{n}{a} + \frac{t}{b} = 1.$$

That is, the change in the index of refraction from 20 deg C. to 21 deg. C. is the same as the change from, say, 42 deg. C. to 43 deg. C, etc.

The constants $a$ and $b$ must be determined for a particular wave-length of light and they will also be different for different substances, although for certain classes of liquids, for example, the ordinary oils and fats, the change in index of refraction per degree C. is practically the same as is shown in Table VI (Tolman and Munson):

TABLE VI—TEMPERATURE CORRECTIONS FOR OILS

| Oil | Decrease in index per °C |
|---|---|
| Linseed | 0.00037 |
| Cotton | 0.00037 |
| Peanut | 0.00037 |
| Corn | 0.00036 |
| Sesame | 0.00037 |
| Olive | 0.00037 |
| Rape | 0.00036 |
| Mean value | 0.000365 |

If, therefore, the refractive index of an oil is 1.47365 at 20 deg. C., at 30 deg. C. it will be 1.47000.

In the case of instruments constructed with arbitrary scales, each division of the scale does not represent necessarily the same increment of refraction so that different corrections must be applied to different parts of such a scale. This will be considered in the next article on Instruments.

Although a temperature correction can be effected, it is always desirable to carry out the determination of the refractive index at some fixed temperature, say, 25 deg. C. This is not possible for two reasons; in the first place, while an instrument may be maintained at a constant temperature without much difficulty, rather elaborate heating apparatus is necessary in order to control the temperature, and, secondly, tables of indices of refraction are not made out for a standard temperature, so that data must be taken for whatever temperature it has been worked out and the necessary temperature correction made.

That the temperature correction changes markedly with the wave-length of the light used is shown clearly by Table VII on dimethylaniline (Falk).

TABLE VII—REFRACTION INDEX OF DIMETHYLANILINE AND TEMPERATURE

| Spectral line | Index of refraction | Change per °C |
|---|---|---|
| C | 1.55296 | 0.000495 |
| D | 1.55968 | 0.000499 |
| F | 1.57765 | 0.000519 |
| G' | 1.59489 | 0.000539 |
| Density | ..... | 0.000825 |

The change which takes place in the dispersion with temperature change is also of interest (Table VIII).

TABLE VIII—DISPERSION AND TEMPERATURE

| | D-C | F-D | G'-F |
|---|---|---|---|
| Dispersion at 10° | 0.00666 | 0.01810 | 0.01722 |
| Dispersion at 80° | 0.00638 | 0.01670 | 0.01582 |

*Density and Temperature.*—The variation of density with the temperature may also be expressed by an equation of the form

$$\frac{d}{a'} + \frac{t}{b'} = 1$$

The effect of temperature change upon refractive index, density, and the specific refraction is shown in Table IX, taken from the work of Falk. This work was all carried out by means of a Pulfrich refractometer.

TABLE IX—DIMETHYLANILINE

| C | $n_c$ | $d$ | $k$ | $k'$ | $k''$ |
|---|---|---|---|---|---|
| 10 | 1.55680 | 0.9648 | 1.4756 | 0.5771 | 0.3335 |
| 40 | 1.54195 | 0.9401 | 1.4654 | 0.5765 | 0.3347 |
| 80 | 1.52215 | 0.9070 | 1.4520 | 0.5757 | 0.3363 |

The density of a solution is, of course, not a simple function of the concentration and therefore there is no simple relation between index of refraction and concentration.

In many cases, however, by means of tables, the concentration can be determined from the density. Since the index of refraction of a liquid can be accurately determined with far greater ease than the density, it is often advantageous to estimate concentrations by means of the refractometer.

In the case of aqueous alcohols, tables have been worked out giving the per cent of water in terms of the refractive index or in terms of the scale divisions of some particular instrument, for instance, the Zeiss refractometer, which is particularly adapted to alcohols. In Table X a few values of such a concentration table (Andrews) are given.

TABLE X—ALCOHOL

| % $H_2O$ | $N_d$ at 25° C | Zeiss Reading |
|---|---|---|
| 0 | 1.35941 | 85.30 |
| 1 | 1.35984 | 86.49 |
| 2 | 1.36024 | 87.60 |
| 3 | 1.36061 | 88.63 |
| 4 | 1.36094 | 89.59 |
| 5 | 1.36125 | 90.45 |

It will be observed from this table that the difference in the Zeiss reading for small changes in concentration is sufficiently large to permit a very accurate determination of the concentration. As might be expected, there is not a constant difference in index of refraction for each per cent difference in concentration. The maximum value of the index is for a solution containing 20.7 per cent $H_2O$.

Another important use of the refractometer, in the case of alcohols, is the determination of the amount of methyl alcohol present in any mixture of ethyl and methyl alcohol. Here a determination of the density is of no value whatever, since the density of absolute methyl and absolute ethyl alcohol is practically the same. Moreover, when they are diluted with the same amounts of water their densities are identical. However, the refraction for ethyl alcohol is much greater than the refraction for methyl alcohol.

From a table given by Leach and Lythgoe, who were the first to make out data for alcohols, a 20 per cent solution of methyl alcohol gives a Zeiss reading of 26.5, while the same concentration of ethyl alcohol gives a reading of 50.5, and the two readings corresponding to a 50 per cent solution are 39.8 and 90.3. For small concentrations the difference is not so great.

It is thus seen that it is a comparatively easy matter to identify the two alcohols by means of the refractometer. If, therefore, the strength of a solution of alcohol is determined from its density, by means of such a table one can determine at once whether the alcohol is methyl or ethyl. Moreover, if it is a mixture, a simple calculation will enable one to determine the per cent of each present.

One of the examples that they give may be of interest. From the analysis of a lemon extract an 18.38 per cent alcohol was found and it gave a reading of 35.8 on the Zeiss refractometer. From their table the readings corresponding to an 18.38 per cent alcohol are 47.2 for ethyl and 25.4 for methyl alcohol. Assuming that the addition of methyl alcohol to ethyl alcohol decreases the refraction in direct proportion to the amount added, the per cent of the methyl alcohol present in the mixture is evidently

$$\frac{47.2 - 35.8}{47.2 - 25.4} \times 100. = 52.3.$$

This classical example is cited to illustrate the use of the refractometer where other simple methods of analysis fail.

No references have been given to tables of indices of refraction, temperature corrections, etc., since these may always be found in books on food analysis or in such standard works as the Landolt-Börnstein Physickalisch-Chemische Tabellen.

Professor Féry has prepared tables of refractive indices of the chief solutions of salts employed in laboratories. Such observers as Chéneveau, Bary, Labrosse, Lebrasseur and Grassot, Warrick (London), Coffignier, Dr. Nicloux, Professor Demerliac, Tixier have also added to the earlier tables and their results are published in part in the Memento du Chimiste of MM. A. Haller and Ch. Girard.

Among other things of importance included in these tables are the following:

Solutions of sulphuric, nitric, hydrochloric and acetic acids.

Alkaline solutions of sodium and potassium.

Solutions of sodium carbonate, of the chlorides of sodium, potassium, ammonium, and zinc.

Solutions of the sulphates of iron, copper, zinc, aluminium and lithium, of potassium bichromate and hyposulphite of sodium.

Mixtures of water and alcohol (ethyl and methyl).

Mixtures of water and glycerine.

Solutions of citric, tartaric, oxalic and tannic acids.

Refractive indices of various organic compounds, refractive indices of essential oils employed in perfumery.

Various other oils, of which a large number of tables have been prepared owing to the industrial importance of this method of analysis.

The following articles may also be of interest: Thèse de M. A. Fancon, "Indices des solutions salines équimoléculaires"; Thèse de M. Chéneveau, "Recherches sur les propriétés optiques des dissolutions et des corps dissons." In both of these articles constant use has been made of the Féry refractometer.

In the next article of this series the most important instruments will be considered in detail.

University of Michigan,
Ann Arbor, Michigan.

---

**Chlorate of Potash in Norway.**—The Frederiksstad Elektrokemiske Fabriker have acquired a secret process for the production of potassium chlorate, in commercial use at present in the south of Europe. Norway has imported heretofore some hundred tons of this product a year. Similar factories, using older processes, are in operation in Finland and in Sweden. The Frederiksstad Elektrokemiske Fabriker has met with much sympathy from the town of Frederiksstad whereby they have secured a favorable power contract under the contract of the town of Frederiksstad with the power company of Hafslund.

The **De Laval Separator Company**, New York, have installed an experimental creamery, as part of their experimental department, in Poughkeepsie, N. Y. It is probably the only creamery in the United States where practically all the milk is separated by hand separators. In addition to cooling vats, pasteurizers, Babcock testers, etc., it also includes the necessary apparatus for making chemical analyses, acid determinations, and physiological investigations and is equipped with special apparatus designed particularly for making delicate tests.

# Titanium-Nitride in Steel

BY GEORGE F. COMSTOCK

In the course of many microscopic examinations of rail steel, both untreated and treated with ferro carbon-titanium, certain hard non-metallic spots came to be recognized as being fairly characteristic of the treated steel and never found in the untreated. These spots were usually very minute, requiring a magnification of at least 200 diameters (preferably 400) to show them clearly; they were never found segregated in streaks or groups, but were always quite evenly scattered throughout the rail's section; they were never elongated in the direction of rolling, but often had angular outlines though usually somewhat rounded in shape; it was difficult to polish a sample containing these spots without pitting, owing to their great hardness as compared with the surrounding metal; and finally when seen with the pure white light of a carbon arc on the ground glass of the metallographic camera, these spots appeared bright pink in color. Their apparent hardness and color were their most characteristic qualities, and it was found that practically all titanium-treated rails contained these pink spots in varying amounts, except those in which the titanium had not produced its usual effect in reducing segregation. The above statement is based on our experience with about forty plain and treated "A" rails (rails made from the top parts of ingots), which have been thoroughly tested and examined here.

The photomicrographs of Figs. 1 and 2 show some of the typical pink inclusions as found in treated rail steel. The section from which these photomicrographs were made was cut parallel to the direction of rolling of the rail, and the lack of elongation of the angular pink inclusions is well shown by comparison with the long thin streaks of manganese sulphide.

The fact that these pink inclusions are never found in steel that has not been treated with titanium proves that titanium must be necessary for their production. An attempt has been made to discover the composition of this hard pink substance, but owing to its finely divided condition and the very minute quantity present in any given sample of treated steel, no pure sample could be obtained for direct chemical analysis. The method followed in attacking this problem was the rather crude one of incorporating various compounds of titanium in samples of untreated rail steels until some substance was found which appeared similar in all respects in a polished section to the characteristic "pink inclusions." Titanium sulphide, carbide and nitride naturally suggested themselves as the compounds most worthy of a trial, and it was also suggested that the spots might be alumina colored by titanium in some form. Practically all the melts of steel with the above compounds were made at the Rensselaer Polytechnic Institute at Troy, N. Y., by Prof. M. A. Hunter, and the titanium sulphide, carbide and nitride used were also supplied by him. The melts were made in an electric furnace in a vacuum, the residual atmosphere in the furnace being carbon monoxide.

The sulphide of titanium was the first compound investigated, and some untreated rail steel was treated with it, but the pink inclusions were not found. Photomicrograph 3 shows this steel as melted by Prof. Hunter in a carbon crucible without any addition. Ordinary manganese sulphide inclusions were numerous in it. Fig. 4 shows this same steel treated in an alundum crucible with ferro carbon-titanium. The characteristic pink inclusions were found here, and are represented in the photomicrograph by the dark angular spots. The faint small rounded spots were also pink in color, but much paler, and are probably some different substance, the identity of which is not important since these pale pinkish rounded spots are not found in ordinary steel. Fig. 5 shows this same steel treated in a carbon crucible with titanium sulphide, and Fig. 6 shows the result of the same treatment done in an alundum crucible. The spots shown in both these photomicrographs had the grayish color typical of manganese sulphide. By comparison with Fig. 3 it is seen that the addition of titanium sulphide to the steel has increased the amount of the ordinary sulphide inclusions and has caused them to be more finely divided, although their color was not changed. Evidently therefore titanium sulphide must mix with the manganese and iron sulphides if it is present at all in melted steel, and it cannot be the substance forming the "pink inclusions."

Titanium carbide was the next substance tried in the endeavor to find the composition of these inclusions. Fig. 7 shows the structure of some fairly pure titanium carbide. The large rounded grains there shown are of a pale violet color, while the streaks between them are very light yellow. The entire mass is very hard and brittle, and the black spots are pits broken out in grinding the section, and which could not be entirely removed in polishing. The violet gray material is the carbide of titanium, and the yellowish material is probably iron carbide or cementite. Fig. 8 shows some steel that was treated with titanium carbide. The smooth areas near the top of the print are carbide, and the spotted substance at the bottom is the steel, full of little dots of carbide. At the boundaries between the large masses of carbide and the steel a feathery, mixed structure was found, as shown throughout the center of this print. This peculiar appearance of the boundaries, together with the occurrence of the small spots of carbide through the steel, indicates that the carbide dissolved in the melted steel, and was more soluble when hot than when cold. Had the mixture been kept long enough at a high temperature, the carbide would eventually have become evenly distributed throughout the steel. None of the characteristic "pink inclusions" were found in this metal, and therefore they cannot be titanium carbide.

The structure of impure titanium nitride is shown by Fig. 9. This substance like the carbide, is very hard and brittle, and it is very difficult to remove by polishing the pits formed in it when the section is ground. The chief part of this alloy, appearing dark gray in the photomicrograph, is bright yellow in color and is probably pure nitride. The light areas shown in the photomicrograph probably represent carbide, and the black areas oxide.

Figs. 10 to 13, inclusive, show samples of rail steel treated with large amounts of titanium nitride. Fig. 10 shows a melt made by Prof. Hunter in an alundum crucible in a vacuum furnace, a large angular fragment of nitride being shown embedded in the steel. This fragment had the characteristic pink color and hard appearance of the "pink inclusions," and smaller typical "pink inclusions" were found scattered in the steel. This steel was from an untreated rail, which had previously been carefully examined and found free from pink spots, like all other untreated steels. Thus the remelting with titanium nitride produced in this case the typical "pink inclusions." In other parts of this small melt some ordinary yellow nitride masses were found, and since the melt was made in an alundum crucible, it was thought possible that the pink color might have been produced only where alumina from the crucible (or perhaps in the original steel) had combined with the titanium or the nitride.

In order to obtain a melt free from alumina as well as from carbon in excess, a small crucible was made from a piece of rail which was known to contain no alumina, and in it some nitride and drillings from the same steel were fused by an arc from an electrode rod of the same alumina-free steel. In this way it was certain that no alumina could be in the product, and the only carbon present was that in the steel used which was from a Bessemer rail. Photomicrographs Nos. 11, 12 and 13 show portions of this melt. In places the nitride seemed to have preserved its original yellow color, but a large amount of it showed the characteristic bright pink color of the "pink inclusions." In places this pink nitride was extensively marked with a dark gray substance, which is believed to be oxide, and Fig. 11 shows the structure where the dark substance was specially abundant. The color of the nitride even here where it was so much oxidized was on the whole distinctly pink. Fig. 12 shows a part of the melt where there was less oxide, and where some smaller particles of the pink nitride were embedded separately in the steel. The steel near the large masses of nitride was full of very small pink inclusions, showing that the nitride dissolved in the steel to a slight extent. Fig. 13 shows some of these very small but typically pink inclusions. It must be remembered, however, that this melt was made with an electric arc, so that extemely high tempeatures were attained in parts of the crucible. Photomicrograph, Fig. 10, compared with Fig. 8, shows that at temperatures sufficient to melt steel the nitride does not readily dissolve while the carbide does.

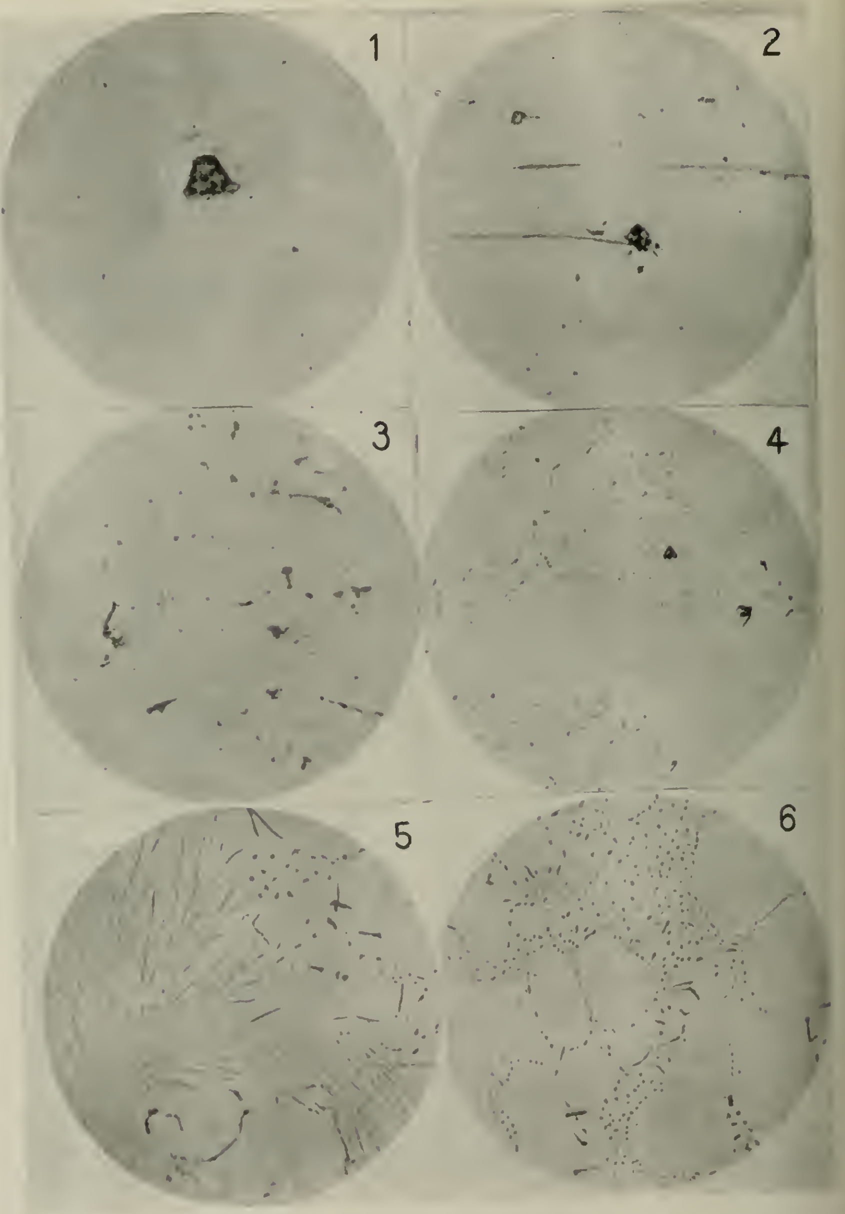
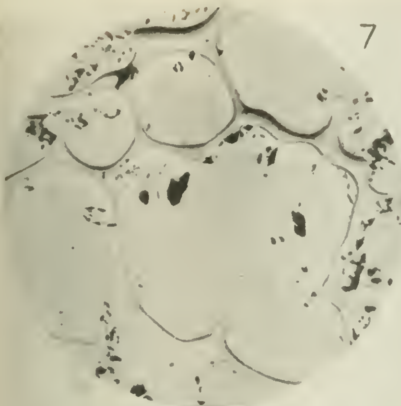
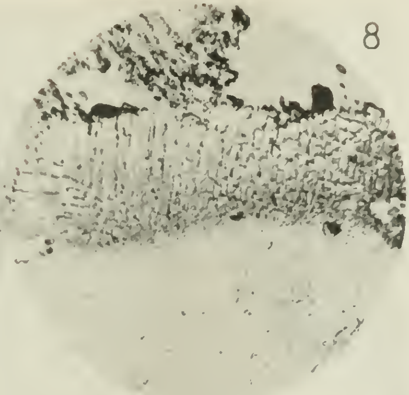


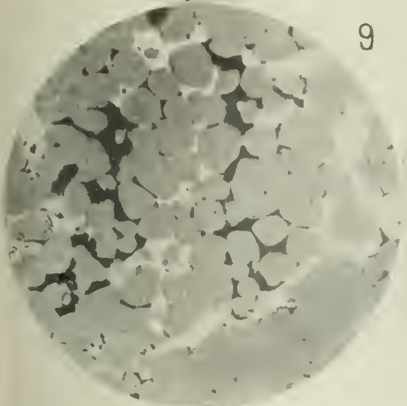
Fig. 1: Longitudinal section in web of titanium-treated rail, magnified 400 diameters, showing angular pink inclusion. Fig. 2. Longitudinal section in web of titanium-treated rail, magnified 400 diameters, showing angular pink inclusions and long fibres of manganese sulphide. Fig. 3: Untreated steel, with manganese sulphide inclusions, magnified 200 diameters. Fig. 4: Treated steel with two kinds of pink inclusions, pale and darker, magnified 200 diameters. Fig. 5: Steel containing manganese and titanium sulphides, magnified 200 diameters. Fig. 6: Steel containing manganese and titanium sulphides, magnified 200 diameters.

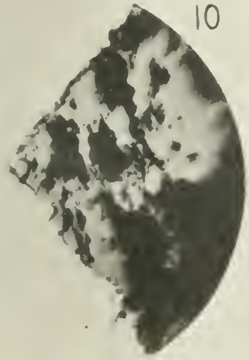
Fig. 14 shows a large skeleton crystal, found in ferrotitanium, made by the alumninothermic method, which had the characteristic color of the "pink inclusions." By dissolving this alloy in acid a residue was obtained of yellowish pink crystals which were found to contain nitrogen. This is in agreement with the view that the pink crystals found in steel are titanium nitride.

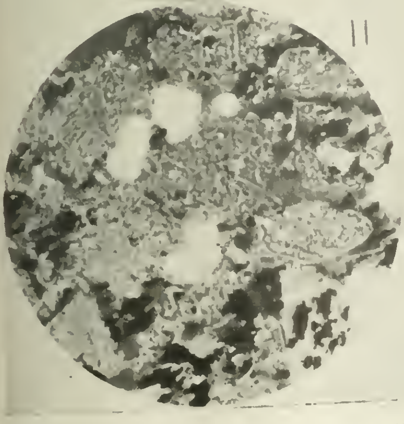
It seems evident from the above experiments that the "pink inclusions" found in titanium-treated rail steel,


7


8


9


10


11

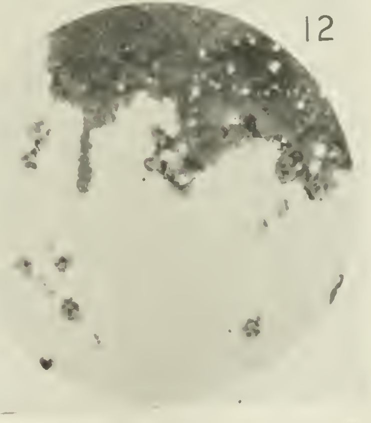

12

Fig. 7: Titanium carbide, light violet grains surrounded by yellowish-white network, magnified 100 diameters. Fig. 8: Titanium carbide above, dissolving into steel below, magnified 200 diameters. Fig. 9: Titanium nitride, bright yellow grains surrounded by light and dark gray substances, magnified 100 diameters. Fig. 10: Steel melted with titanium nitride in alundum crucible, magnified 400 diameters. Fig. 11: Titanium nitride melted and oxidized in steel crucible, magnified 400 diameters. Fig. 12: Pink titanium nitride in steel, magnified 400 diameters.

and not found in untreated steel, are composed largely if not entirely of titanium nitride, and that while carbon and iron may enter into their composition, alumina does not. Photomicrographs Figs. 15 and 16 are of interest in this connection. Fig. 15 shows an alloy of "pure" Swedish iron with 5 per cent of pure metallic titanium, and Fig. 16 shows a similar alloy of Swedish iron with ½ per cent of aluminothermic ferrotitanium alloy. These alloys were melted in a vacuum furnace and in alundum crucibles. The angular inclusions shown in Fig. 15 had the yellow color of titanium nitride, and the small rounded spots were very pale pink like the inclusions shown in Fig. 4. The metallic titanium must have combined with the nitrogen in the Swedish iron to form the yellow nitride, and possibly the total absence of carbon from this alloy is the reason for the pink color not being shown. Photomicrograph 16 shows a streak of alumina inclusions, their color being very dark blue. No pink or yellow inclusions were seen in this alloy, although some titanium was present with aluminium. Alumina has been identified in ordinary steels and occurs in very small dark bluish particles, very hard to polish without pitting, and often arranged in streaks.

It is unfortunate that chemical confirmation cannot be obtained for the identification of the "pink inclusions" as titanium nitride, but no reliable method is known for the quantitative determination of nitrogen in this form. An average of many nitrogen determinations made here by an improved method on titanium-treated rails shows a distinctly lower amount present than in untreated rails, but this difference in nitrogen content of the metal may be due to the locking up of some nitrogen by titanium in the pink inclusions, or to the actual removal of nitrogen from the liquid steel bath,

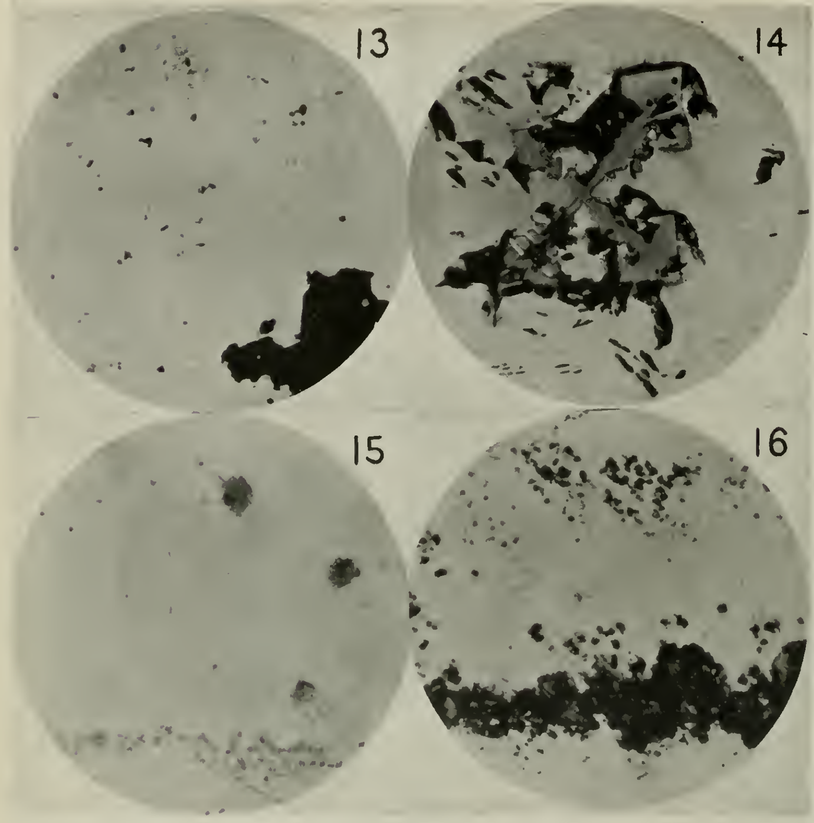


Fig. 13: Pink inclusions of titanium nitride in steel, magnified 400 diameters. Fig. 14: Crystal of pink titanium nitride in aluminothermic ferrotitanium, magnified 200 diameters. Fig. 15: Pure 5% ferro-titanium, with yellow nitride crystals, magnified 400 diameters. Fig. 16. Alumina from aluminothermic alloy in iron, dark blue in color, magnified 400 diameters.

or to both effects combined. At any rate, if it is assumed that nitrogen has an injurious effect on steel, the lower amount found by analysis must be an advantage, for even if the whole amount removed from the metal itself is still present in the pink inclusions, it could have no more ill effect in this form than any other non-metallic inclusions of the same size. As the titanium nitride inclusions are never found segregated in groups or streaks, but are always very small, scarce and thinly scattered, their weakening effect on the metal is practically negligible. It is hardly possible that the nitrogen contained in the pink inclusions could have been derived from any other source than the bath of steel to which the titanium was added, as the regular ferro carbon-titanium does not show these pink spots. Therefore their presence in a treated steel must mean that some nitrogen has been removed from solution in the metal, and this removal must be a distinct benefit, if as some authorities claim, nitrogen is very injurious when dissolved in steel.

The fact that titanium nitride is present in certain steels must not be taken to mean that all the titanium found in them by chemical analysis is present in that form. Some of it, of course, must be, but the quantitative estimation of this compound in a given steel is a problem that has not yet been solved either chemically or otherwise. It is entirely possible that a considerable amount of titanium may be present as carbide in steels that contain the pink nitride inclusions, as well as in those that do not.

It has been found in examining a great many titanium-treated rails, that, in all except a few which contained no titanium nitride, the sulphide inclusions were smaller and more evenly distributed than in the untreated rails. This is a fact which it is hard to explain theoretically, but an interesting confirmation is shown by the steel treated with titanium sulphide (Photomicrographs 3, 5 and 6), which showed much finer sulphide inclusions than the same steel untreated.

This work is described and published with a view chiefly toward interesting metallographists and aiding them in identifying the pink titanium nitride crystals. It is believed that they have not been described before in the literature of non-metallic inclusions in steel, and a familiarity with their appearance and composition should be valuable as affording a means of knowing that steels in which they are found had been treated with titanium.

The conclusions to be drawn from the work described above are that these hard pink inclusions are composed chiefly if not entirely of titanium nitride, and that while they may also contain some carbon or iron, alumina is not necessary for their formation.

Physical Laboratory,
Titanium Alloy Mfg. Co.,
Niagara Falls, N. Y.

---

**Foot-Rule.**—A four-joint two-foot rule of Starrett make is being sent by the Ashland Fire Brick Company of Ashland, Ky., to its friends on request. It is a very attractive and useful souvenir.

**The probable increase in tin production** in the Malay peninsula, due to the introduction of dredges and modern methods of production, is the subject of editorial comment in the *Malayan Tin & Rubber Journal*. This authority anticipates that, as the result of increased output, the price of tin will reach a lower level in the next two years. Nineteen dredges are now at work, and as many more are to be built.

**Idaho's output** of gold, silver, copper, lead and zinc in 1913 was valued at $24,149,049, according to the Geological Survey. The production of all metals except gold increased. The Coeur d'Alene region showed a marked increase in production of silver, lead and zinc.

# The Electric Arc Furnace and the Development of the Steel Casting Industry

BY IVAR RENNERFELT

Recently a very interesting article written by Mr. G. Muntz appeared in the METALLURGICAL AND CHEMICAL ENGINEERING (June, 1914). Its object was to call attention to the special features of the converter process for making steel castings and to compare this older method with the new electric process for melting steel, which is rapidly forcing its way to the front.

It may be well worth while to investigate the correctness of several of the points brought forward in said article in favor of the converter process, as the reader, unless familiar with the modern electric arc furnace, is liable to get an erroneous idea of the relative merits of the two processes. Of course, no one will or even can deny that the small bessemer converter has assisted greatly in developing the steel foundry, but it is also undeniable that the converter has drawbacks due to its construction and to the limited range of materials for which it is adapted.

The electric furnace, on the other hand, although a comparatively new tool, has already proven itself to possess advantages which are sure to open for it a very wide field of operation. Even if we know something about electric steel melting, more remains to be discovered and invented before we have fully demonstrated its many possibilities. The first practical electric furnace for melting steel was started hardly a decade ago and it is, therefore, difficult to forecast what will be the development of the next ten years. Most of the difficulties have been overcome and rules for the design of the electric furnace have been established on the basis of a considerable practical experience with a number of different types, used for different purposes.

### Economy

The first condition for economical melting of steel electrically is cheap energy. Hydroelectric power is generally the cheapest; but even medium-size steam or gas-power stations should be able to generate and sell energy at a cost sufficiently low to justify the running of a steel furnace. For the economical working of a steel foundry the continuity of operation is, however, an equally important factor at least if power is bought on the kw-year basis.

It has been found that an electrical steel foundry is well able to pay 1 cent per kw-hr. and still make a handsome profit, especially if a fair proportion of the output consists of light or difficult castings which will bring a good price per pound.

It is certainly to be expected that a well-situated and carefully managed central station can sell furnace energy at 0.5 cent per kw-hr. without losing money.

### Ease of Operation

The electric arc furnace, if properly designed, is very easy to handle. It will melt any kind of iron or scrap that is put into it rapidly and without oxidation. No special haste to discharge the furnace after the heat is completed is necessary as the charge may be kept in the furnace for any length of time without any material change in its composition. As a matter of fact, the steel is really improved by remaining in the hearth for some time before pouring as slag and gases thereby are given an additional chance to rise to the surface, rendering the steel more homogeneous and solid. This method of treating a ready charge of steel would be entirely out of question in the bessemer converter or the open-hearth furnace.

Should the molding work so demand, the pouring off may, therefore, be delayed and the steel delivered as required. The converter steel, on the contrary, must be teemed as soon as possible after completion of the heat, as it is impossible to maintain for any length of time the temperature required for making good castings.

### Refining Possibilities

The electric furnace is especially a refining tool by means of which the poorest kind of scrap iron may be transformed economically into the highest grade of cast steel. No other furnace can compete with the electric furnace in this respect.

The acid bessemer converter can deal only with a premelted charge of high-quality pig iron of closely limited composition, which determines the quality of scrap of high grade which may be added in the converter. In the acid open-hearth process we find the same reactions, but under better control, and with a wide range of raw materials. The basic open-hearth can deal with impure, low-grade materials and can to a certain extent reduce P and S. But neither of the above processes has as wide a range or as perfect control of the results as the electric arc furnace in which any element entering into the charge can be eliminated, practically to any extent desired.

### Remelting Foundry Scrap

In every steel foundry a considerable precentage of metal melted remains in the form of risers, runners, lost castings, etc. This refined metal is very conveniently remelted in the electric furnace and constitutes a first-class raw material. The proper composition of the charge is easily controlled by adding pure ore or mill scale to reduce carbon or pig iron, coke or coal to increase it. There does not exist the slightest difficulty in controlling carbon and the opinion of Mr. Muntz on this point is decidedly not warranted by the actual facts. If properly used, the electric furnace permits a much closer control of all the elements of a charge than any other melting apparatus, not even barring the crucible in which the control of carbon, silicon and manganese is far from easy.

The use of the Tropenas or Bessemer converter is limited by the quality of the raw materials, as every one familiar with metallurgical operations knows. The pig iron must be very high grade, low in P and S and high in Si and Mn. The machinery builders are continually raising their standards and will soon not be satisfied with steel castings containing any considerable amount of the ill reputed elements S and P. The cupola melting of the pig is always liable to introduce a certain amount of S into the pig iron, as all ordinary coke holds a good deal of this dangerous element.

### Smaller Loss from Oxidation

It is well known that in a well-designed and closed electric furnace a neutral or even a reducing atmosphere may be maintained.

No air enters the furnace and should any enter, when the door is opened, its oxygen will soon be consumed by the carbon of the white-hot electrodes. If the charge consists of pure steel scrap, practically no loss will take place as there is no oxidation. This is, of course, a very valuable feature, especially if the furnace is used for making alloyed steel castings from high-priced raw materials, which as a rule are very easily oxidized.

The converter is, contrary to this, known to cause a very considerable loss on account of oxidation. The raw material is twice exposed to the influence of the oxygen; first in the cupola and then in the converter. It is stated that with a small converter this loss amounts to not less than 12 to 15 per cent even with careful management. The loss may, however, under favorable conditions amount to even 28 to 31 per cent (Manual of the Metallurgy of Iron, Prof. E. G. son Odelstierna, Stockholm, 1913).

This loss means not only high cost, the pig iron used being high-grade and expensive, but it also introduces an undesirable uncertainty regarding the chemical composition of the steel. The pig iron used should contain 1.5 to 2 per cent Si but not more than 0.2 to 05 Mn in order to save the lining of the converter which would suffer considerably if the charge contained more Mn. These two elements Si and Mn serve as the source of heat in the converter and are, of course, a very expensive fuel. The converter process is liable to cause a considerable amount of scrap due to the low temperature of the steel in the ladle, risers and defective castings, which has to be remelted in the cupola. If this amount is large the molten cupola metal is liable to run low in Si and Mn and may, therefore, not produce steel of the proper temperature for casting it in molds.

The electric furnace is entirely independent of what percentage of scrap is put into it and can even run on scrap only. In this case the loss by oxidation is insignificant, provided that the scrap charged is clean and free from rust.

### The Supply of Raw Material

It has been supposed that a more general application of electric furnaces to foundry purposes would cause a shortage of steel scrap, raising the price of raw material to a prohibitive limit. It is, however, hardly possible that a prohibitive rise in price of scrap will be caused by the electric furnace as this is able to convert almost any kind of scrap, even such as is practically unfit for use in the open-hearth furnace which is by far the largest consumer of steel scrap. Should a rise take place, this will, therefore, more seriously affect the open-hearth steel plants and most likely a number of these plants may be replaced by bessemer converter works supplemented by electric refining and deoxidizing furnaces. Such a transformation would make large quantities of scrap available for the electric smelting furnaces at probably even lower prices than now paid by the steel works.

But the electric furnace is also suitable for the pig and ore process, receiving molten or melting a charge of pig to which is added enough ore to decarbonize the charge. For this method the consumption of energy is not prohibitive. According to tests made by the Ljusne Ironworks in Sweden it may be expected that steel can be made from pig iron and ore with a consumption of not more than 850 kw-hr. per ton, starting with a cold charge. This decarbonizing process is also suitable for removing a certain amount of phosphorus from the pig iron, thereby improving the resulting steel. The phosphorus is, of course, removed only at the end of the melting, when the percentage of carbon hase been sufficiently reduced, i.e., to 0.10 per cent or less.

If using high-grade pig iron the process may be stopped as soon as the carbon is reduced sufficiently to meet the specification for the castings. Naturally the decarbonizing can be interrupted by pouring off part of the charge at, say, 0.60 per cent C and then adding more iron ore to reduce the carbon to 0.20 per cent or less, if extra soft castings are required. This operation is performed with ease permitting the steelmaker to take all the time he wants for testing his steel in any way desired.

### No "Hit or Miss" Method

The electric steel furnace makes it possible to turn out heats of steel of practically exact chemical composition. The carbon may be lowered or increased at will and additions may be made for making various kinds of alloyed steel. The quantities which in each case should be added to obtain a certain specified percentage of nickel, chromium, vanadium, etc., can be closely calculated. Sulphur and phosphorus may be reduced to practically nil if desired by simply "working" the charge with a sufficient number of refining (basic) slags, melting them one after the other, carefully removing each preceding slag before adding a new one.

The limit for this refining is only the consideration of cost. The consumption of energy and time will, of course, increase if very low-grade materials are to be converted into high-priced tool steel. The fact that a remarkable degree of refining is possible in the electric furnace is well known, quoting, for instance, Mr. E. F. Lake (*Iron Age*, March 27, 1913). In his article on "European electric steel castings" this author makes the statement that "for various reasons high-grade steel castings can not be made with the open-hearth process," and he adds "the Bessemer process need not be mentioned, as it is well known to be less adapted to such work than the open-hearth and only *applicable to very cheap castings*." Speaking about the small converter which is a close development of the Bessemer furnace, Mr. Lake states that "this process has its limitations, however, and it is best adapted to medium grades of steel castings. The extra-fine grades require the crucible or electric furnace process for melting and refining."

The conclusion to be drawn from this is that it is certainly advisable for any steel foundry of importance to make arrangements for a suitable electric furnace in its plant. Only if this is done can the customers be assured of strictly high-grade steel, when such is required. And this is going to be frequently demanded in the future when designers and builders of machinery know that such high-grade steel castings are obtainable at short notice and at reasonable cost.

The proper course for a steel foundry would be at first to erect a furnace of medium size, say, 1 to 1½ tons capacity, to work together with the converter or whatever melting furnace may be in use. The most difficult and expensive castings could then be taken care of by the electric furnace leaving it to the converter or open-hearth to produce the lower and cheaper grades of work. This would be a natural development, greatly facilitating the more general introduction of higher grades of castings by means of this new melting tool.

### Capacity of the Electric Furnace

The electric furnace when used to melt cold steel scrap is to be considered especially as a refining furnace intended more to produce quality than quantity. The time for finishing a heat depends not only on what quality of steel is wanted but also on the power available. It is possible to overload an electric furnace thereby obtaining quick melting and increased output, but if persisted in this, of course, will injure the lining of the furnace and increase the cost of maintenance. This is the case also with the converter, if it is used for a very forced work such as melting 6 tons of steel in one hour in a 2-ton converter.

Should it really be required to accumulate 4 to 6 tons of steel having available only a 2-ton electric furnace, this might be done by overheating the first and second charge considerably and pouring them in a properly designed and thoroughly preheated mixer. By properly lining the mixer it is possible to avoid loss of heat, causing the steel to cool off only very slowly.

The electric steel may therefore be kept hot for several hours without getting below the casting temperature. The steel in such a mixer may, of course, be kept hot also by means of an oil- or gasburner or by introducing a few pounds of thermit ($Al + Fe_2O_3$) which generates a very large quantity of heat, when the finely powdered aluminium is brought to react and combine with the oxygen in the iron ore. This method, of course, involves an extra cost per ton of steel, but circumstances may justify such an occasional expense.

The Tropenas converter is always lined with acid brick. These do not stand a higher temperature than about 1650° C., the fusing point of brick being at 1700 to 1750°. Ordinary soft steel congeals at about 1450° and it is consequently not possible to overheat the steel more than 200° without spoiling the lining of the converter. The electric furnace again, if lined entirely with basic materials permits maintaining the temperature at about 2150° C. or 500° higher than is possible in the converter. The electric steel, therefore, may be poured into the basic-lined receiver at a temperature which is some 700° C. above the melting point of the steel. The electric furnace is the only one in which it is possible to produce really superheated steel of first-class quality.

### Segregation

It certainly is a remarkable statement of Mr. Muntz that the electric furnace produces greater segregation than the Tropenas converter. The consensus of opinion of leading authorities is the opposite. Without doubt the electric furnace is very much effective compared to other melting tools in preventing segregation.

Mr. W. R. Walker read before the American Iron and Steel Institute, May, 1912, a paper on "the electric furnace as a possible means of producing an improved quality of steel," in which he states that ingots of even 8 tons have been produced electrically which are "practically free from segregation."

### Wide Market for Electric Steel Castings

Quite contrary to the concluding statement by Mr. Muntz that the electric steel does not find a ready market is the fact that there is a wide demand for just such high-grade steel castings as can only be produced from the electric furnace. The machinery trade is constantly raising the standard specifications whenever there is the slightest chance that public safety would be endangered on account of low-grade steel being employed for important details. Builders of automobiles, locomotives, airships, elevators, carriages, street and railway cars, etc., all recognize the importance of specifying the best quality of steel obtainable at reasonable cost.

This is a well established practice in both Europe and America. The writer is in a position to testify to this, because of his connection with certain interests devoted to the economical and practical development of one of the most promising of the electric steel furnaces now in the market. The amount of inquiries for electric furnaces coming in from all parts of the world, and especially from the United States, is astonishing and is a sure indication of the future electric steel melting. People are beginning to realize that the electric furnace has come to stay, but that it is by no means "foolproof." It is quite possible to spoil steel in several ways and it must not be expected that any person not familiar with steel generally should be able to use the electric furnace to best advantage. If, however, the quality of the steel in any charge is not satisfactory, it is in most cases possible to correct this by making proper additions to the bath, keeping it long enough to obtain exactly the steel which is wanted.

If handled with reasonable care and intelligence the electric furnace is really a most useful and easily managed melting apparatus, certain to play an important role in the future development not only of the steel casting industry but in the whole art of iron and steel making.

Aktiebolaget Elektriska Ugnar,
Stockholm, Sweden.

## Goslar Convention of the Association of German Metallurgists

The annual meeting of the Association of German (non-ferrous) Metallurgists and Mining Men (Gesellschaft Deutscher Metallhütten- und Bergleute) was held from July 3 to 6, 1914, in Goslar in the Hartz Mountains.

After various visits to mines and metallurgical plants in the neighborhood the meeting was opened on the evening of Friday, July 3, by a speech of the president of the association, Mine Director **Niedner**, of Tarnowitz, in Upper Silesia.

Bergrat **Wolff** then lectured on some of the geological and technical problems of the Rammelsberg mine.

On Saturday, July 4, various other industrial plants were visited and an excursion was made to Hartzburg. In the evening a social meeting was held at which two American engineers, **H. N. Stronck** and **J. F. Boyle**, lectured on scientific management in mining and metallurgy. The subject of their discussion was the problem how with higher wages it is possible to reduce the cost of operation in mining and metallurgy on the basis of the principles of scientific management.

The business meeting was held on Sunday, July 5. Bergrat **Volgelsang**, of Eisleben, was in the chair. The membership is now more than 800. The organ of the society is the journal "*Metall und Erz.*" A special section has been formed for zinc metallurgy, and at the first meeting of this section Director **Holey**, of Duisburg, had lectured on the roasting of zinc blende.

Papers were then presented by Professor **Krusch** on possible platinum deposits in Germany and by Director **Juretzka**, of Breslau, on the metallurgy of zinc. The author pointed out that on account of the rise of the price of lead and zinc various new processes have been introduced into practice. He discussed recent improvements in the manufacture of retorts and in the drying of the retorts and gave the results of experiments on the winning of zinc in vertical retorts. He also discussed the problem of zinc smelting in shaft furnaces.

Finally Mr. **Bueler de Florin**, of Aussig, read a paper on the use of nitric acid for the leaching of ores, giving a review of various processes which have been proposed in this field. Kingsley and Rankin have proposed to let nitric acid react with sulphide ores, especially lead sulphide. Kingsley intends to produce a lead nitride solution. Rankin intends the formation of lead sulphate which is possible with the use of concentrated acid at a raised temperature with stirring and the application of two atmospheres pressure. The Norsk Hydro-Elektrisk Kvaelstoffaktieselskab has proposed a treatment of ores containing bismuth as sulphide or oxide in small quantities. The author has proposed leaching copper oxide or carbonate ores rich in lime and free from sulphur with diluted nitric acid.

In all four processes the regeneration of the acid forms an important step. How this is carried out in the four processes is shown in the following equations:

*Kingsley:*

Treatment of ore:

$$3PbS + 8HNO_3 = 3Pb(NO_3)_2 + 2NO + 4H_2O + 3S$$

Regeneration of acid:

$$Pb(NO_3)_2 + Na_2CO_3 = PbCO_3 + 2NaNO_3$$

$$2NaNO_3 + H_2SO_4 = Na_2SO_4 + 2HNO_3$$

*Rankin:*

Treatment of ore:

$$3PbS + 8HNO_3 = 3PbSO_4 + 8NO + 4H_2O$$

Regeneration of acid:

$$2NO + 3O + H_2O = 2HNO_3$$

*Norsk Hydro-Elektrisk Kvaelstoffaktieselbskab:*

Treatment of ore:

$$Bi_2O_3 + 6HNO_3 = 2Bi(NO_3)_3 + 2H_2O$$

Regeneration of acid:

$$Bi(NO_3)_3 + H_2O = BiONO_3 + 2HNO_3$$

Büeler:

Treatment of ore:

$$CuCO_3 + 2HNO_3 = Cu\ (NO_3)_2 + H_2O + CO_2$$

Regeneration of acid:

$$Cu\ (NO_3)_2 = CuO + N_2O_5$$

$$N_2O_5 + H_2O = 2HNO_3$$

The treatment of ores with nitric acid is, however, sensible only if the nature of the ores or the local conditions exclude the use of other methods. After the close of the meeting a banquet was held and on Monday, July 6, a visit was paid to the Rammelsberg mine.

---

## Some Economic Aspects of Industrial Chemistry*

BY DR. BERNARD C. HESSE

In considering this subject the difficulty lies not in a scarcity of material, but principally in keeping the discussion of the voluminous matter within a small compass.

Taking the thirteenth census of the United States as a guide in ascertaining what is regarded by the Census as industrial chemistry, it will be found that in the division of chemical and allied products, metals and all metallurgical operations are excluded, as well as the production of refined petroleum, and a host of other large industries such as glass, soap, pottery, sugar, starch and the fermentation industries which depend upon chemical reactions and chemical control for their successful execution.

The Census of the United States includes under chemicals and allied products nine principal divisions:

1—Paint and varnish.
2—Chemicals.
3—Fertilizers.
4—Explosives.
5—Dyestuffs and extracts.
6—Sulfuric, nitric and mixed acids.
7—Wood distillation (not including rosin and turpentine).
8—Essential oils.
9—Bone, carbon and lampblack.

For the present, these nine divisions of the Census will be considered. Having arrived at a tentative conclusion as to the scope of the subject matter, this subject matter will be considered from the two following aspects:

I—The relationship of these industries to the manufacturing industry of the United States as a whole.

II—The position of the United States in those respects as a buying and selling nation.

The volume and distribution of foreign trade of the United States in the fiscal year of 1913 is given by the Department of Commerce as follows:

| | |
|---|---|
| Exports | $2,428,506,358 |
| Imports | 1,812,978,234 |
| Total | 4,241,484,592 |
| Excess of exports | 615,528,124 |

In order to obtain a conception of the relationship of these nine branches of chemical industry to the manufacturing industries of the United States as a whole, Table I will be helpful.

The story told by Column D is encouraging in some respects, and is not so encouraging in others. Compared with other manufacturing industries, the chemical and allied industries do not so easily lend themselves to small units. It takes 3.3 times as much capital for the average chemical plant as for the average manufacturing plant. This is the discouraging feature from the individual point of view.

From the broader point of view, Column D, however, is very encouraging. The average chemical plant requires 50 per cent. more help than the average manufacturing plant; it employs over two and a half times as many salaried employees as does the average manufacturing plant, but unfortunately only 34 per cent. more than the average number of wage-earners. The average chemical plant bears much more than its proportionate share of expenses, whether in the shape of salaries, wages, materials, or miscellaneous expenditures; in the value of the product produced per unit of chemical plant the average chemical plant produces 161 per cent. more than its average share.

If the principal object of manufacture be the enhancement of value of the outgoing material over the incoming material, then the fact that the average chemical plant enhances its raw material 148 per cent. more than its average share is a matter for congratulation and of encouragement.

Turning now to the question of productive power of capital invested in chemical industry, it will be found on inspecting Column E that a dollar is not so productive in the chemical and allied industries, average against average, as in the other branches of manufacturing endeavor. The disbursements for salaries, materials, power, value of product and expenses of miscellaneous nature are each about three-quarters of the average of the same items for the other branches of manufacture, and the enhancement in value is only 75 per cent. of the average enhancement produced by unit capital investment in the other branches of manufacture. The dollar so invested employs fewer wage earners, salaried or otherwise, than a dollar otherwise invested in manufacturing enterprise. This, of course, is merely a natural consequence of the high initial cost of plant, the large size unit of plant required and the close markets.

Turning to the value of products in Column B, it is to be noted that the percentage participation of each of the nine divisions in that title is as follows:

| | | | |
|---|---|---|---|
| Paint and varnish | 29.4 | Sulfuric, nitric and mixed acids | 2.3 |
| Chemicals | 27.4 | Wood distillation | 2.3 |
| Fertilizers | 24.5 | Essential oils | 0.3 |
| Explosives | 9.4 | Bone, carbon and lampblack | 0.4 |
| Dyestuffs and extracts | 3.8 | | |

The thirteenth census of the United States has distributed the participation of these nine divisions in this amount of product with considerable detail, which does not lend itself very well to discussion. The not specifically described items amount to $73,563,059, or 17 per cent. of the total. For the purpose of obtaining a better understanding of the relationship of the various principal items under each of these nine divisions, Table II has been prepared.

Within the nine divisions given, the United States is in a large measure self-sustaining, although it is necessary for it to obtain much of the raw material from abroad. In the division of dyestuffs and extracts, and particularly that portion of it dealing with artificial dyestuffs, it is to be noted that during 1913, the total importation into the United States of artificial dyestuffs, exclusive of alizarine dyes and indigo, amounted to $7,105,284; during the census year of 1910 this country manufactured $3,462,436 worth of such artificial dyestuffs which amounts roughly to 32 per cent. of this country's entire consumption of the so-called coal-tar dyes; no doubt, since the census year 1910, the domestic production of coal-tar dyes has increased. However, much of the coal-tar raw material used in such manufacture comes to us from abroad, particularly from Germany and England.

In the fertilizer division we are, of course, dependent for our potash requirements, upon Germany, and these

---

*Lecture delivered at the College of the City of New York on May 1, 1914. Slightly abstracted.

TABLE I.

Comparison of Chemical and General Manufacturing in Continental U S

| | Items | A<br>Total | B<br>allied products | C<br>Percentage of A in B | D (a)<br>Ratio of Aver chem. plant to Av general manuf. plant | E (b)<br>Average in chemical plants for $1 investment |
|---|---|---|---|---|---|---|
| | | Manufacturing establishments | | | | |
| 1 | Number of establishments | 268,491 | 2,140 | 0.79 | .... | 0.30 |
| 2 | Persons engaged in manufactures | 7,678,578 | 88,097 | 1.15 | 1.44 | 0.44 |
| 3 | Proprietors and firm members | 273,265 | 1,155 | 0.42 | 0.53 | 0.16 |
| 4 | Salaried employees | 790,267 | 16,516 | 2.09 | 2.64 | 0.80 |
| 5 | Wage earners (average No.) | 6,615,046 | 70,426 | 1.06 | 1.34 | 0.40 |
| 6 | Primary horsepower | 18,680,776 | 398,880 | 2.14 | 2.71 | 0.82 |
| 7 | Capital | $18,428,270,000 | $183,729,410 | 2.62 | 3.31 | .... |
| 8 | Expenses | 18,453,080,000 | 359,425,126 | 1.95 | 2.46 | 0.74 |
| 9 | Services | 4,365,613,000 | 62,700,767 | 1.44 | 1.82 | 0.55 |
| 10 | Salaries | 938,575,000 | 24,042,566 | 2.56 | 3.24 | 0.98 |
| 11 | Wages | 3,427,038,000 | 38,658,201 | 1.13 | 1.43 | 0.43 |
| 12 | Materials | 12,141,791,000 | 258,115,975 | 2.13 | 2.69 | 0.81 |
| 13 | Miscellaneous | 1,945,676,000 | 38,608,384 | 1.98 | 2.51 | 0.76 |
| 14 | Value of products | 20,672,052,000 | 125,084,540 | 2.06 | 2.61 | 0.79 |
| 15 | Value added by manufacture (value of products less cost of materials) | 8,530,261,000 | 166,968,565 | 1.96 | 2.48 | 0.75 |

(a) Values obtained by dividing separate items in C by Item 1 in C.

(b) Values obtained by dividing separate items in C by Item 7 in C

TABLE II.

Analysis of Chemical and Allied Products by Divisions.

| Paint and Varnish Industry. | Value in Dollars | Percentage of Total Division |
|---|---|---|
| Pigments | 16,985,588 | 13.6 |
| Paints in oil | 56,763,296 | 45.4 |
| Varnishes and Japans | 31,262,535 | 25.0 |
| Fillers | 3,126,271 | 2.5 |
| Water paints and kalsomine | 1,979,007 | 1.6 |
| Linseed oil | 1,912,594 | 1.5 |
| Bleached shellac | 578,650 | 0.5 |
| All other products | 12,281,481 | 9.8 |
| Total | 124,889,422 | |
| CHEMICALS | | |
| Acids | 11,926,389 | 10.1 |
| Sodas | 21,417,982 | 18.1 |
| Potashes | 88,940 | 0.7 |
| Alums | 2,578,842 | 2.2 |
| Coal tar products | 2,675,327 | 2.3 |
| Cyanides | 1,941,893 | 1.6 |
| Bleaching material | 1,635,046 | 1.4 |
| Chemical products made by the aid of electricity | 17,968,277 | 15.2 |
| Plastics | 7,180,172 | 6.1 |
| Compressed and liquefied gases | 4,969,805 | 4.2 |
| Fine chemicals | 10,956,666 | 9.3 |
| Chemicals not elsewhere specified | 34,349,548 | 29.1 |
| Total | 117,688,422 | |
| FERTILIZERS | | |
| Fertilizers | 92,369,631 | 88.8 |
| Superphosphates | 13,318,529 | (12.8) |
| Ammoniated fertilizers | 10,061,193 | ( 9.7) |
| Concentrated phosphate fertilizers | 3,638,210 | ( 3.5) |
| Complete fertilizers | 57,243,899 | (55.0) |
| Other fertilizers | 8,107,800 | ( 7.8) |
| Sulfuric acid for sale (as 50° Bé. acid) | 923,492 | 0.9 |
| Other acids for sale | 611,288 | 0.6 |
| All other products | 10,055,802 | 9.7 |
| Total | 103,960,213 | |
| EXPLOSIVES | | |
| Dynamite | 18,699,746 | 16.6 |
| Permissible explosives | 863,209 | 2.2 |
| Nitroglycerin | 3,162,434 | 7.9 |
| Blasting powder | 9,608,265 | 24.9 |
| Gunpowder | 1,736,427 | 4.3 |
| Other explosives | 3,913,787 | 9.7 |
| Materials not elsewhere specified | 2,155,793 | 5.4 |
| Total | 40,139,661 | |

| Dyestuffs and Extracts | Value in Dollars | Percentage of Total Division |
|---|---|---|
| Artificial dyestuffs | 3,462,436 | 21.6 |
| Extracts for dyeing | 991,974 | 6.2 |
| Extracts for tanning | 6,449,105 | 40.4 |
| Other tanning materials | 625,401 | 4.0 |
| Mordants | 99,797 | 0.6 |
| Sizes and finishes | 2,418,652 | 15.0 |
| Ground and chipped woods, etc. | 344,761 | 2.2 |
| All other products | 1,562,448 | 9.7 |
| Total | 15,954,574 | |
| SULFURIC, NITRIC AND MIXED ACIDS | | |
| Sulphuric acid | 5,629,496 | 57.0 |
| Nitric acid | 499,303 | 5.1 |
| Mixed acid | 1,438,475 | 14.6 |
| All other products | 2,316,783 | 23.5 |
| Total | 9,884,057 | |
| WOOD DISTILLATION (not including rosin and turpentine) | | |
| Wood alcohol: | | |
| Crude | 1,627,878 | 16.7 |
| Refined | 2,901,709 | 29.8 |
| Acetate of lime | 1,981,220 | 20.3 |
| Charcoal | 2,351,644 | 24.0 |
| Turpentine | 249,526 | 2.6 |
| All other wood distillation products | 357,290 | 3.7 |
| All other products | 267,731 | 2.8 |
| Total | 9,736,998 | |
| BONE, CARBON AND LAMPBLACK | | |
| Bone black | 1,070,333 | 50.0 |
| Carbon black | 625,514 | 29.3 |
| Lampblack | 439,707 | 20.6 |
| Total | 2,135,554 | |
| ESSENTIAL OILS | | |
| Oil, peppermint | 519,079 | 29.8 |
| Oil, black birch | 102,045 | 5.9 |
| Oil, spearmint | 83,283 | 4.8 |
| Oil, wintergreen | 68,983 | 3.9 |
| Other oils | 335,213 | 19.3 |
| Witch-hazel extract | 412,322 | 23.7 |
| All other products | 216,309 | 12.4 |
| Total | 1,737,234 | |

amount in round numbers to $1,000,000 per month. In the same division we are dependent upon Europe for much of the ammonia entering into the fertilizers, amounting in 1910 to over $4,000,000. It will probably not be long before most of our ammonia requirement is supplied by our own by-product coke-ovens.

## Industrial Chemistry in Its Broad Aspect

However, industrial chemistry or chemical industry is much broader in scope than is indicated in the thirteenth Census of the United States on chemicals and allied products. From the point of view of the person with chemical training, every industrial operation which calls for chemical control is a branch of industrial chemistry or of chemical industry, the two terms being used interchangeably.

In Germany the official classification of material connected with chemical industry is as follows: 1—Malt, oil, fruits, plants, etc. 2—Industrial or medicinal vegetable products. 3—Tanning extracts. 4—Resins, gums and adhesives. 5—Caoutchouc and camphor. 6—Animal and vegetable fats and oils. 7—Animal products. 8—Starch and sugar. 9—Alcohol, acetic acid, mineral waters. 10—Mineral and fossil raw materials. 11—Ores, iron and slags. 12—Fossil fuels. 13—Mineral oils and like fossil raw materials. 14—Coal-tar oils and products. 15—Waxes. 16—Soap and fat products. 17—Chemical and pharmaceutical products. 18—Miscellaneous chemical and pharmaceutical products. 19—Dyes and dye materials. 20—Ethers and alcohols. 21—Volatile oils, synthetic perfumes, toilet articles. 22—Artificial fertilizers. 23—Explosives and combustibles. 24—Wood fiber and chemical paper. 25—Metals.

These twenty-five large classes or divisions comprise four hundred and forty-two sub-classes.

An examination of the records of imports and exports into and from the United States during the fiscal year 1913, discloses a total business of $4,241,484,592; of this, not less than $1,302,274,994 or 30 per cent. deal with products of chemical industry or materials used in the products of chemical industry, and of these $759,193,688, or 18 per cent. of the total represents imports and $543,081,306, or 12 per cent. of the total represents exports leaving a balance of trade against the United States, $216,112,382.

LARGE ITEMS IN CHEMICAL TRADE OF THE U. S. FOR 1913.

| | |
|---|---|
| IMPORTS | |
| Sugar | $204,212,581 |
| Hides and skins | 117,386,174 |
| Unmanufactured India rubber | 101,333,158 |
| Paper and paperstock | 27,706,697 |
| Potash compounds | 14,408,124 |
| | $465,046,734 |
| EXPORTS | |
| Refined petroleum and its products | $139,882,905 |
| Copper as metal | 120,605,914 |
| Beef and hog products | 82,890,777 |
| Leather | 42,384,199 |
| Naval stores | 26,471,492 |
| Fertilizer material | 11,400,888 |
| Cement industry | 5,822,107 |
| | $429,458,282 |

Information as to the distribution of the exports and imports just given as to countries of destination and countries of origin is not readily assessible, since it would be a never ending task for the officials of the Department of Commerce to rearrange all of this vast information from the various points of view possible.

### Movement of Chemical Products Between Germany and the United States

However, fragmentary information is accessible with respect to the relationship between the United States and Germany as regards the interchange of chemical products between the two countries. This information is based upon German official publications.

From the point of view of values, information is at hand for only the year 1904. In that year Germany sent to the United States $16,993,200 worth, and the United States sent to Germany during that time $38,194,240, or an excess in favor of the United States of $21,201,040, which means about $1,800,000 per month.

With regard to the tonnage movement between those two countries, information for the year 1913 is at hand, and it shows that during that period a total of 3,430,564 metric tons of commodities of the chemical industry passed between the two countries, of which 1,917,430 metric tons passed from the United States to Germany, and 1,513,134 metric tons passed from Germany into the United States; that is, the United States sent to Germany an excess of 404,000 tons over what it took from Germany in 1913.

### Freight Movements in the United States

In 1911 the total freight movement over the railroads of the United States amounted to 967,233,991 tons; of these about 14 per cent. comprised manufactured goods, and about 28,000,000 tons of the total freight moved was composed of products of chemical industry, that is, about 3 per cent of the total freight movement of this country is represented by products of chemical industry. The three and a half million tons gross above referred to between the United States and Germany, therefore, represent about 12 per cent. of the probable total freight movement of products of chemical industry in this country.

### Efficiency of American Industrial Chemistry

An examination of the relative exports and imports of products of chemical industry from and into the United States shows that there is little, if any, ground for criticism of American chemists in not utilizing their opportunities. It is safe to say that the American chemical industry is developing its own natural resources with a degree of foresight and success very favorably comparable with that accomplished by chemists in other lands. Much is heard in criticism of American chemists for not developing a coal-tar chemical industry, but I do not believe such criticism to warrant a wholesale belief in the backwardness of American chemists. There can be no question that the chemical work involved as well as the engineering work involved in the production of a useful and usable illuminating oil, or a medicinal preparation from crude petroleum, compares very favorabily with the chemistry involved and the engineering involved, in the production of the majority of so-called coal-tar dyes. The relative economic value of the two products is, of course, in favor of the products of petroleum.

It will be sufficient to say Germany is supreme in the coal-tar dye industry, because (1) Germany was the home of the industry; (2) the industry itself is so dependent upon interlocking chemicals and the growth of this interlocking dependence has been as fast as economic development warrants and has now reached such a stage of complexity and interdependence that it is difficult of transplantation as a whole; (3) there are relatively few so-called staple articles among the coal-tar dyes—by staple is meant those which are consumed in quantities to be measured by tons—many of those few are so interlocked with subsidiary or by-products that the transplantation of the work out of Germany would be economically unprofitable.

Wherever it has been profitably transplantable to this country, the manufacturing of such staples has been done, and with considerable success even though the raw material supply is still provided by Europe.

### Theory and Practice

The chemical industry, probably more than any other industry, is dependent upon the application of much theoretical work, i. e., scientific work to every-day conditions, and in order that the chemical industry may grow, it is necessary that there should be brought to bear upon the manufacture of each and all of the products the highest chemical training available under the circumstances. The beneficial interaction of practice upon theory and theory upon practice, is evident in almost every branch of industrial chemistry. It has been brought to its highest efficiency, however, in the organic division and more particularly that dealing with coal-tar dyes and synthetic medicinals and pharmaceuticals. However, the chemist can, with profit follow Mr. Kerr's excellent advice to engineers when a difficulty is encountered: "Go as far as you can see and then see how far you can go."

The simplification brought about in organic chemistry through the creation of the Kekulé conception of the structure of benzol, made the development of the coal-tar dye industry in its early stages possible, or at any rate immeasurably facilitated it. In return, the coal-tar dye industry has enriched scientific or theoretical organic chemistry with a wealth of information and facts with respect, not only to benzol, but to naphthalene, anthracene and the higher aromatic hydrocarbons; the two working together have developed a very large number of new classes of organic compounds, for example: the azines, oxazines, numerous classes of azo compounds and the wealth of oxy and oxyamido derivatives in all the classes. New methods of sulfonation, chlorination and nitration have been developed almost without number, and in turn, theoretical organic chemistry has supplied the industry with many useful methods of the same kind.

To contemplate the results of this interaction is to view one of the greatest of intellectual triumphs. It is this very fact that has misled so many to ascribe to the coal-tar dye industry an economic effect far beyond its actual and to belittle the economic effect of the so-called inorganic industry. It is perfectly safe to say that the money value of the inorganic exceeds the money value of the dye industry by at least 15 to 1.

From 1877 down to the close of 1912 there were taken out in Germany 5,675 German patents, or 158 per year, dealing with the utilization of coal-tar hydrocarbons and their by-products; it has been estimated that not more than one out of every hundred has secured financial returns for its owners. During the years 1895 to 1903, 382 German patents, or at the rate of 48 per year, were taken out in the inorganic chemical industries.

It would be an interesting subject for speculation to consider the intellectual effort involved in the 5,675 coal-tar patents as compared with the intellectual effort required for the 382 inorganic patents. It would also be of interest to consider the difficulties, financial and otherwise, in the way of creating those respective patents. A far-reaching experiment can be made in the coal-tar industry for a very little expenditure of material and labor, but in the inorganic industry the expenditure of material and labor is inordinately greater. You can make a coal-tar dyestuff and determine whether there are any probabilities of its having commercial utility at an infinitely slighter expense than you can determine whether certain alterations in the construction of a bleach-chamber in the production of bleaching powder will or will not be profitable; on the other hand, as you approach the more highly developed and almost completed manufacturing phase of coal-tar dye chemistry, you immediately come into about the same difficulties and embarrassments that you do in the inorganic field, and for precisely the same reason, namely, that in both cases you are endeavoring to develop refinements, and refinements are much more difficult of detection, elaboration and application than is the question of determining whether you have, or have not, a new and probably useful dyestuff.

By way of illustration, there are probably fewer than 35,000 compounds listed in Beilstein, but it will be no difficulty whatever to find a dozen different patents on coal-tar dyes, each and every one of which covers several million, even several hundreds of millions of different and distinct dyestuffs. Of course, to discover a new type of a dyestuff is almost as difficult as it is to discover a refinement in the almost fully developed inorganic industry, but once the type is given, there is no difficulty in creating a new dyestuff under that type.

### The Function of the Chemist as an Individual

Now, the function of the chemist in the production of things is twofold. Take the apparently most humble position, namely, that of analyst. Upon his accuracy of manipulation depends, in a large measure, the profitableness of the undertaking. If an analyst makes a mistake of 1 per cent. in determining copper, on the $120,000,000 worth that we export annually, that would mean a loss of $100,000 per month. Therefore, analytical control, in order to be of value, must be accurate, since inaccuracies can easily run into large sums of money.

But the chemist's contribution does not stop merely with control; he does create a great many new uses for old things, and he does create new things and find uses for them. To be able to do these things to the best advantage, he must be thoroughly versed in what has been done, must know what tools are at his command, must be able to use those tools and to tell when they shall be used, must possess also the merchant's instinct of values, if he desires to rise to the highest efficiency in industrial chemistry. Of course, he must know how to handle men, and how to get results with what is at his command, as must anyone who attempts to conduct any business enterprise.

He must be alert, and he must overcome any disdain that he may naturally have for small things, for in industrial chemistry, perhaps oftener than in any other, it is the small thing that has pointed the way to achievement and success.

It is an old story how the production of benzol from coal gas was brought about by a mistaken notion that oxalic acid could be made from coal gas and nitric acid. An alert and very observant chemist in repeating this attempted synthesis found not only that oxalic acid was not formed, but that nitrobenzol was produced with benzol dissolved therein. That was the beginning of the recovery of benzol from coal gas, and the addition to the sources of benzol of a source much greater and more dependable than any theretofore available.

The neglect of a laboratory boy to maintain the temperature he was directed to keep in a certain vessel, taught that laboratory boy nothing, but the chemist in charge following up this result, finally ended up with a method of substituting sulfuric acid for bromine, thereby reducing the cost of production by over 50 per cent. In both of these cases it is very doubtful if a man having no training beyond that required in the production of the things with which he was directly concerned, would ever have made those discoveries. The attempt to make oxalic acid would have resulted in failure, and would have been so reported, the result of the laboratory boy's negligence would have been dumped into the sewer, and a new start made along the original lines.

### Conclusion

I have shown how, in a national sense, the chemical industry contributes a very substantial portion to our national welfare and the useful part it plays in this work-a-day world, in the employment of persons, materials and of capital; how in a broader sense it touches almost every field of human activity; how it is interwoven with the means required for the gratification of all our personal needs and desires.

It needs merely to be mentioned in order to bring about a full appreciation of the importance of the chemical industry to refer to the important part it plays with respect to agricultural chemistry. The chemical methods of investigation and research applied to agricultural problems indicate the requirement of certain materials by the soil, and these materials are supplied by the chemical industry. In that way the chemical industry contributes to the activity of the soil and the increased output per unit area of agricultural products.

Conversely, as in the case of alizarin and indigo, hundreds upon hundreds of square miles of the earth's surface were devoted to the cultivation of the plants necessary to produce these articles. This very large area is no longer required for that purpose, and it is safe to say that in the chemical factories now producing these things the combined working area is under four square miles. Right or wrong, I have always personally felt that had the botanist devoted the necessary attention to the growth and cultivation of indigo plant when the first synthesis of indigo was announced in 1880, the displacement of vegetable indigo between 1897 and 1900 by synthetic indigo would not have taken place, or at any rate, it would not have been accomplished after so brief a struggle. The botanist has assisted wonderfully in increasing the alkaloidal content of cinchona barks, and in the discovery of a large number of new plants capable of producing a latex suitable for India rubber production and he has also contributed greatly to the development of plantations, wherein the yield per unit area is much increased.

While at the present day it may not be commercially profitable to produce synthetic rubber, or synthetic camphor, or synthetic nitric acid, or synthetic ammonia, yet it is perfectly true that the very existence of these possible synthetic sources of these materials renders it less and less likely that there will be any undue advance in the cost to the consumer of these articles; at any rate, the cost will not be advanced beyond a figure where the synthetic process can achieve a reasonable profit.

Chemical industry, therefore, not only provides for our present needs, but acts as safety device against famine, shortage or undue monopolization of a number of vegetable and mineral products.

## Features in Work of Bureau of Standards

Secretary of Commerce Redfield has just received a report from the director of the Bureau of Standards relative to the work of that bureau which shows how many interesting features there are in the varied and extensive work of testing and investigation being conducted by that bureau.

For some time the bureau has been working on *safety rules* to be observed in the operation and maintenance of electric generating stations and substations, and on the overhead and underground distributing wires in connection therewith, and a set of rules has been prepared for publication by the bureau.

The report on mitigation of *electrolysis damage* in Elyria, Ohio, has beeen completed and was presented to the city, the gas company, the telephone company and the railway company some weeks ago and accepted by all the interests involved. The railway company has promised to do everything recommended by the bureau, which will result not only in correcting very serious electrolysis troubles but also will improve the street-railway service in Elyria and vicinity, improve the lighting of the cars and save enough money to the railway company to justify fully the total expense involved apart from the consideration of electrolysis mitigation. This is to be accomplished by a rearrangement of their distribution system and the installation of negative cables for the return of street railway current to the power stations. Because of these economies the railway company is willing to undertake the expense of new construction and new arrangement without recourse to city ordinances or pressure from the courts.

In the *cement laboratory* in Washington tests were made from samples for delivery of about six thousand barrels. At the Northampton laboratory the June shipments sampled and tested represented 66,700 barrels of cement, an average daily rate of 2565. It is interesting to note in this connection that the total shipments tested at this laboratory now aggregate 6,158,108 barrels, mainly for the Panama Canal.

About two months ago an instrument was constructed for the United States Weather Bureau for measuring the so-called *nocturnal radiation*, which usually is a loss of heat from terrestrial substances into space. The latest report shows that this instrument is unusually sensitive and that it meets all the requirements.

The influence of atmospheric conditions on the *testing of sugars* has long been an unknown quantity owing to the difficulty of controlling both temperature and humidity in the research laboratory. Relatively large and inexplicable differences have been noted for some years between the tests on imported sugars for the collection of duty at the various ports of entry. So great have been these differeces that sugars have purposely been imported via certain ports with the intent of paying a lower rate of duty. The bureau has studied this question, and its investigation now shows not only the exact cause of differences but also a simple and certain method of eliminating them.

One of the interesting and important pieces of work has been the establishment of a *standard of radiation* of which not merely the light in a visible spectrum was measured but the total radiation visible and invisible was accurately determined. These determinations have been completed with four radiometers and show most excellent agreement as to results, within 0.5 per cent compared with the previous calibration of these lamps. Hence the standard of radiation as defined by these laamps may be considered well established. This standard is quite distinct from standards of light.

## Program of Chicago Meeting of the American Institute of Metals

The eighth annual meeting of the American Institute of Metals will be held in Chicago from Sept. 7 to 11 (Monday to Friday).

Monday, Sept. 7: Registration La Salle Hotel.

Tuesday, Sept. 8, 10 a. m.: Joint meeting with the American Foundrymen's Association, Hotel La Salle. Subject: "Safety Work."

Safety and Foundry operations, address by M. W. Alexander, General Electric Company, West Lynn, Mass.
Safety First, by F. W. Reidenbach.
Progress in the Safety First Movement, by Arthur T. Morey.
Safety in Connection with Grinding Wheel Operations, R. G. Williams.
Safety in Sanitation, by A. W. Gregg.
Safety First—Driving Back the Saloon, by Thomas D. West.

Tuesday, 2 p. m., Hotel La Salle: General papers and reports.

Report of Official Chemist, by Arthur D. Little, Inc.
Progress in the Nomenclature of Alloys, by G. K. Burgess.
Some Recent Applications of Metallic Cobalt, D. B. Browne
Drop Pouring Process of Casting, by E. A. Barnes.
Bull Run Tale, by Jesse L. Jones.
Modern Die-Casting Practice, by Charles Pack.
Die Cast Aluminum, by A. B. Norton.
Non-ferrous Alloys for Automobile Construction, E. B. Horne.

Wednesday, Sept. 9, 10 a. m.: Saddle and Sirloin Club, Stock Yards. Cost Congress. Joint session with A. F. A.

Foundry Cost Keeping, by F. J. Stevenson.
Efficiency in Foundry Operations, the Essential Factor in Reducing Production Costs, by A. K. Hathaway.
Efficiency in Foundry Work, by F. A. Parkhurst.
Revision of the A. F. A. Standard Foundry Cost System, by Harrington Emerson.
Practice in Estimating Selling Price of Castings, by A. O. Backert.

Wednesday, 2 p. m.: Rolling Mills; Physical and Chemical Testing.

Care and Conversion of Rolling Mill Scrap, by W. W. Rogers.
A Brief Visit to a Rolling Mill, by Edward J. Gutsche.
A Hot Shortness Testing Machine for Aluminium Alloys, by A. B. Norton.
Making Aluminium Test-Specimens on Castings, by A. B. Norton.
Standard Test Bars of the Zinc and Bronze, Copper 88, Tin 10, Zinc 2, by C. P. Karr.
A New Method for the Determination of Zinc in Alloys, by G. E. Lundell and Mal Kim Bee.
Brinnell Hardness Testing of Non-Ferrous Alloys, V. Skillman

Thursday, Sept. 10, 10 a. m.: Saddle and Sirloin Club, Metallurgy and Metallograph.

Commercial Classification of Copper, by Lawrence Addicks
Spelter Manufacture and Properties, by George C. Stone.
Metallurgy of Tin and Antimony, by W. A. Cowan.
Ternary Alloys of Copper, Tin and Zinc, by S. L. Hoyt.
The Effect of Repeated Remelting on Copper, by F. O. Clements.

Thursday, 2 p. m.: Melting Practice.

Tests of Electric Furnaces for Brass Foundry, Herbert G Dorsey.
Electric Furnace for Medium Temperatures, by E. M. Schmelze
Electric Brass Melting from the Central Station Viewpoint, by H. M. St. John.

Friday, Sept. 11, 10 a. m.: Saddle and Sirloin Club.

Melting Losses in Electric Brass Furnaces, by H. W. Gillett and J. M. Lohr.
Use of Producer Gas in Melting Yellow Brass, by E. H. Guenther
Test of Natural Gas Fired Furnaces under Factory Conditions, by Fred L. Wolf and Robert B. Burr.
Electric Brass Melting, by G. H. Clamer and Carl Hering.
Pyrometers for Melting Brass and Bronze, by H. W. Gillett

# Utah Meeting of American Institute of Mining Engineers

The Utah meeting of the American Institute of Mining Engineers proved after all a tremendous success, featured by cordial hospitality, elaborate entertainment, and excellent technical sessions, in which metallurgical papers predominated. Owing to the somewhat unsettled conditions of the Western mining field, there had been a doubt whether it would not be better to postpone the meeting, and recommendations to that effect had been made by Utah and Colorado members. But cooler council fortunately prevailed and the meeting was held exactly according to the program in almost every point. The only notable omission was the trip on Tuesday to the Arthur concentrating mill, which had been closed down.

The attendance was large and high-class. The registration list showed 340 names.

After an organ recital at the Mormon Tabernacle in the afternoon of Monday, Aug. 10, and an automobile trip through Salt Lake City, the meeting was officially opened on Monday night in the ballroom of the Hotel Utah by President B. B. THAYER.

D. C. JACKLING welcomed the society to Salt Lake City and reviewed the mining and metallurgical developments in Utah and the contributions of Utah engineers to progress in the industry.

The subject of the technical session which followed and in which R. C. GEMMEL presided was a symposium on copper leaching, papers being presented by Messrs. Laist and Aldrich, Laist and Frick, Austin, Croasdale, Laist and Wiggin, Holt.

## Copper Leaching

### Leaching at Anaconda

The paper by **Frederick Laist** and **Harold W. Aldrich** discusses "Experimental Leaching at Anaconda." The object of the construction and operation of the 80-ton leaching plant was to test out the leaching of sand tailings on a large scale and, if possible, determine a definite method of operation, and the best construction for the larger unit which is now being built. It was also of importance to obtain some practical data as regards cost items.

The 80-ton plant was not expected to be a commercial success. A leaching process on such low-grade material necessitates the treatment of a very large tonnage. Such a cost item as labor, for instance, is entirely out of proportion in such a small plant. The amounts of acid, salt, scrap iron, and fuel for roasting, however, are the same per ton in an 80-ton plant as in a 2000-ton plant. These costs were definitely established. Also the percentages of extraction and grade of tailings were definitely determined for a large-sized unit.

The equipment of the plant and the gradual changes which were made in equipment and method of operation are described in great detail in the paper. Originally the six-hearth MacDougall roaster was designed for oxychloride roasting and salt was added on the fourth floor. After a 50-day successful run it was decided to discontinue the feeding of salt into the furnace and see what results could be obtained. This method offered many advantages. No valuable metals were volatilized and no accretions formed in the furnace to cause trouble. The extraction on the copper was even better than on the chloridizing roast, but the silver recovery was not so good.

For the detailed results of the tests the reader must be referred to the complete paper (*Bulletin* Amer. Inst. Min. Eng., August, 1914, p. 2165). It must suffice here to give the chief general results:

The feed from the mill averages between 0.65 and 0.70 per cent. copper, about 5 per cent. moisture, and about 3 per cent. sulphur. Ninety tons per 24 hr. of this feed can be roasted in a 20-ft. MacDougall furnace of the type used with a coal consumption of 2.75 per cent. of its dry weight. The calcine will contain about 0.6 per cent. sulphur. About 40 per cent. of the copper is water-soluble.

It requires about 20 per cent. of the weight of the calcine in weight of solution to saturate the charge. This assumes the solutions at a specific gravity of 1.00, while in reality they have a specific gravity of about 1.25.

It requires about 40 per cent. of the weight of the charge in wash water for a reasonably good wash.

The acid consumption will not exceed 50 lb. $H_2SO$ per ton of charge and the salt lost in solution discard will not be more than 1 per cent. of the weight of calcine, probably much less. By figuring acid consumptions on each leach, and using acid content of each solution, before going on and after coming off the calcine, the acid consumption on the first 14 leaches averages about 25 lb. per ton. On the last six, 50 lb. of acid per ton was added. This may have given somewhat better results, but not very much so. It seems as though perhaps the extra acid of the 50-lb. consumption was used in taking up iron and alumina, and had very little effect on the copper remaining in the charge.

The silver has a tendency to precipitate on the lead linings to a small extent. This would not offer much difficulty, as the lead rapidly becomes coated and precipitation ceases. The solutions, on cooling and on the addition of water, drop some of the silver out as silver chloride. This forms in the bottom of the solution tank to more or less extent and has to be cleaned up periodically. All of the silver in solution precipitated in the scrap-iron launders with no trouble whatever.

Under conditions which would apply in a large plant, it is expected that an 85 per cent. extraction can be made on the copper, and very probably 86 or 87 per cent. A tailing carrying between 2 and $2\frac{1}{4}$ lb. of copper per ton should be made. In a plant as small as the 80-ton plant, and built for temporary use, a great many petty annoyances are encountered, as the running of the furnace, and therefore of the whole plant, depended on so many small pieces of machinery in the conveying and cooling equipment. Not 10 per cent. of the furnace shutdowns were caused by troubles with the furnace itself. Naturally, the furnace does much better roasting, and with less coal consumption, when it is running continuously or nearly so.

No salt is necessary in the roast for the better extraction of the copper. It would increase the silver extraction from 75 to 90 per cent, but this extra 15 per cent of the silver recovered would not pay for increased cost of salt, installation, and operation of an apparatus to catch the values in the gases. This recovery of fume values would probably not be much over 90 per cent. The chloridizing of the silver is done in the leaching tanks.

### Precipitation of Copper from Solution at Anaconda

The paper on this subject by **Frederick Laist** and **F. F. Frick** points out that there are three general classes of precipitation methods: First, the use of iron, scrap

PHOTOGRAPH TAKEN AT THE UTAH MEETING OF THE AMERICAN INSTITUTE

or sponge; seconds, electrolytic deposition, and third, the use of some gas or reagent by which the copper is obtained, usually in the form of an intermediate precipitate which requires further treatment. For example, the precipitation of the copper as $Cu_2Cl_2$ from chloride solutions, with $SO_2$ gas.

The use of iron is adapted to almost any process. It has the great advantage of extreme simplicity, and the recovery of the copper and any values present in a highly concentrated, easily treatable form. The disadvantages are the cost in isolated places, the uncertainty of the scrap-iron market, and the fouling of the leaching solutions. The latter is a serious factor, when a reagent such as salt is used in them, which makes necessary their re-use.

Where applicable, electrolytic deposition is very attractive. The copper is obtained in a form directly marketable, there is a regeneration of acid and no fouling of solutions. Unfortunately, chloride solutions do not lend themselves to electrolysis. An entirely satisfactory anode material has not yet been discovered, although magnetic, apart from being rather brittle, seems to answer the requirements fairly well.

The use of a method of the third class is involved in many special leaching processes, and is highly attractive theoretically. Such methods usually involve regeneration of leaching solutions, no fouling of solutions, and the use of some cheap reagent, as lime, or a by-product of the process itself, or of some process such as smelting. Some method of this kind is undoubtedly that of the future where electrolytic deposition is not applicable.

The copper solution from the 80-ton leaching plant, in which the sand-treatment method now being installed on a large scale was developed, averaged Cu, 1.91; $Fe_2O_3 + Al_2O_3$, 3.88; NaCl, 8.3 per cent.; Ag. 0.634 oz. The copper content of this solution cannot be increased much economically. The application of this solution to successive lots of roasted tailing, from which about 10 lb. of copper per ton can be recovered, would necessitate excessive washing of the tailing. The copper can be precipitated from this solution by means of scrap iron, the cement copper going directly to the blast furnaces or converters. The use of sponge iron is more attractive than the use of scrap iron, however. It can be made from calcines which contain about 50 per cent. iron. This makes the process independent of the scrap-iron market. But the use of iron necessitates the discard of about one-fourth of the solution each time to stop the accumulation of iron sulphate, and this leads to the loss of much valuable salt.

Owing to its high chlorine content the solution is not adapted to electrolysis. With a view to getting something better than scrap iron, precipitation experiments have been and are being conducted on precipitation by sulphuretted hydrogen made from matte (also from calcium sulphate), sponge iron from calcined concentrates, and sulphur dioxide from roasting-furnace gases.

The authors describe first their experiments with hydrogen sulphide as precipitant, then with sponge iron, and finally precipitation with sulphur dioxide.

To reduce the cuprous chloride, the authors have developed three different methods. First, precipitation with sponge iron ($Cu_2Cl_2 + Fe = 2Cu + FeCl_2$). Second, reductions with coke with limestone present to flux and hold the chlorine. Third, electrolytic reduction. The results obtained with these three methods are described in the paper.

The final conclusion of the authors is as follows:

At present it seems advisable to precipitate the copper directly from the copper solutions of the 2000-ton sands-leaching plant with sponge iron. The precipitation of the copper from such solutions with sponge iron is being worked out and promises to be simple. Until the leaching process is established on a definite operating basis it does not seem advisable to introduce a complicated precipitation method.

The acid plant now building will have ample capacity for the first 2000-ton leaching unit. When the time comes to build further units, the installation of an $SO_2$ precipitation plant will depend on considerations of first cost of acid and precipitation plants, cost of operation and other factors which undoubtedly will develop.

### Leaching Copper Products at the Steptoe Works

The paper by W. L. Austin describes a small copper-leaching annex to the Steptoe metallurgical plant, where ore of the Nevada Consolidated Copper Co. is beneficiated. This copper-leaching annex has been treating flue dust from roasting-furnace dust chambers, together with a siliceous oxidized ore. This leaching plant was designed to obviate smelting low-grade siliceous flue dust, which interfered with the operation of the reverberatories by forming a blanket on the charge.

The major portion of the copper content of the

OF MINING ENGINEERS WITH MINE OF UTAH COPPER COMPANY AS BACKGROUND

flue dust accumulating in the upper chambers of the roaster flue, and at the stack, is water soluble, and also contains much free sulphuric acid and soluble sulphates. It was found that sufficient acid could be obtained by mixing this material with water to provide a lixiviant for leaching the siliceous copper ore mentioned. This was the sole source of the lixiviant.

The flue dust analyzed copper 3 per cent, $SiO_2$ 23, Fe 4., CaO + MgO 3., $Al_2O_3$ 6., free $H_2SO_4$ 20., $SO_3$ combined as sulphate 25., $H_2O$ combined with the sulphates 11, O 2.5. Copper soluble in dilute $H_2SO_4$ 2.56.

The oxidized ore, locally known as "carbonate," contains 3.5 per cent Cu, 71 $SiO_2$, 2 Fe, 9.5 $Al_2O$ — Copper soluble in dilute $H_2SO$ 3.23. The copper in this ore is largely mineralized as silicate.

The method of operation pursued at the Steptoe plant consists in hydraulicking the piles of flue dust which have been withdrawn from the dust chambers, as an economical means of dissolving the soluble contents and of transportation to the tanks. The stream of water is conducted to vats, or impounded in dams, where the mud is allowed to settle. The clear solution resulting, which contains the soluble salts and is now the lixiviant, is drawn from these reservoirs to a wooden vat, fitted with a filter bottom. This is the ore-leaching vat proper. It is 40 ft. in diameter and 10 ft. deep. It is filled with crushed "carbonate" ore to a depth of 7 ft.; the ore column through which percolation of ¼-in. material is effected is therefore about 7 ft. high.

The excess space in this vat is used to store the lixiviant, for the hydraulicking operation is intermittent, while ore leaching is continuous. Enough lixiviant is accumulated above the charge in this vat to continue leaching during the night.

If the filtrate from the ore leaching vat (the lixivium) still contains considerable free acid, it is pumped back and passed through the ore bed a second time. Otherwise it is allowed to flow through a filter of "carbonate" ore, and thence over scrap iron placed in precipitating boxes.

About 85 per cent of the free acid carried by the lixiviant is utilized in the ore-leaching vat, the remaining 15 per cent. being left in the lixivium flowing over the scrap iron, to prevent formation of basic iron salts and insuring clean precipitate. About 2 lb. of scrap iron are consumed per pound of precipitate produced.

The cost of the copper recovered from the flue dust and siliceous "carbonate" ore capacity is approximately 8 cents per pound.

### Leaching Experiments on the Ajo Ores

The paper by **Stuart Croasdale** gives a full account of the experiments carried out by him on the treatment of ores from the New Cornelia copper mine, Ajo mountains, Arizona, for the Calumet & Arizona Copper Company. Incidental with this problem was the utilization of a large amount of low-grade pyrite in the Bisbee mines of the company, provided this could be accomplished by any feasible method.

The ore deposit is unusual. It consists of an intrusive plug of monzonite or granite porphyry. Chalcopyrite, bornite, and magnetite are finely disseminated throughout the magma in sufficient quantities to make the greater part of the mass commercial ore to a certain depth.

The conditions of the problem demanded simplicity of process and large scale of operations. Two methods of *leaching* treatment were available, and both are entirely reliable and feasible under the conditions involved. One of these is the old Henderson process of roasting with salt, and the other is leaching the raw ore with sulphuric acid. Under the head of "chloridizing roast with salt," the author includes the so-called sulphatizing roast of Mr. Wedge, in which he finds the addition of a small percentage of salt very beneficial; and also the modification used by Mr. Laist at Anaconda, in which he reduces the consumption of salt, as well as the losses by volatilization, by giving the ore a preliminary roast before adding the salt.

A comparison of these two methods may be made briefly as follows:

By using the chloridizing roast, all ores on the property could be treated by the same process—oxidized, sulphide, and intermediate. This would mean the construction of only one plant. The average extraction of the copper would probably be higher than that obtained from acid leaching and the small amount of silver in the ore would be recovered to a large extent. By mixing the ores, little if any sulphur would have to be added as pyrite. The only chemicals required would be salt, to the extent of 5 to 10 per cent. of the ore treated, and possibly a small amount of pyrite ore. Both of these could be transported in ordinary freight cars. There would be less corrosive solutions to handle. There would be a minimum amount of iron and alumina passing into solution. There would be no appreciable absorption of copper by slimes.

On the other hand, this method would require dry crushing of the ore to 20 or 40 mesh, which would be troublesome if not prohibitive on the oxidized ores on account of the difficulty in controlling the poisonous dust, in addition to the expense of grinding. It would involve a roasting cost. It would mean a more expensive plant, for the same capacity of operation, mainly on account of the slower percolation of the fine material, which would require a much larger vat area of less depth to hold the tonnage required. It would mean a supply of cheap salt. A chemical precipitant would probably have to be used to recover the copper.

By leaching with sulphuric acid, the oxidized ore can be treated raw and need not be crushed finer than ½ in. or 2-mesh size, or perhaps coarser, as the experiments of the author have shown. Owing to the high oxidation of the surface ores and apparently small zone of partly oxidized ores, a large tonnage can be expected to give a comparatively high extraction by this method. Sulphuric acid can be made as a by-product at the roasting plant of the Calumet & Arizona Company at Douglas, or if the calcines are converted into sponge iron and used as a precipitant for copper, the low-grade pyrite from Bisbee can be cheaply transported and acid made at the mine. If electrolytic precipitation can be used, a small percentage of the acid consumed can be regenerated. This method of extraction will permit of less expensive plant construction for the oxidized ores.

On the other hand, sulphuric acid alone will extract none of the copper existing as sulphide, only half of the copper existing as cuprite, and may be indifferent about the silicate of copper. It will extract none of the precious metals. Owing to the character of the oxidation of the ore, considerable iron and alumina pass into solution as readily as the copper, which will seriously interfere with any form of electrolytic precipitation and render the amount of acid regenerated a doubtful asset when compared with the amount consumed. As an offset to this objection, some of the iron is in a ferric condition, which assists materially in the solution of the minerals mentioned above.

If acid is made at Douglas, it will have to be transported several hundred miles in tank cars, which will have to be returned empty. If acid is made at the mine from low-grade pyrite, a gain will be made in transportation, but the cost of an acid plant will be added to the cost of the leaching plant and the calcines will have to be utilized. Almost an entirely new plant will have to be constructed for treatment of the intermediate and sulphide ores.

The problem is clearly one in arithmetic as well as metallurgy.

Laboratory experiments were made with both methods, experimental plant tests only with the acid leaching process. These tests are described in great detail in the paper.

The second part of the paper deals with *precipitation* of the copper from solution. The following precipitants are discussed: Natural sulphides of iron (unsuccessful, as far as the experiments went); artificial sulphides of iron (a failure); sponge iron (it seems feasible to metallize calcines for copper precipitation at a cost of not over $5 per ton of metallic iron); pig iron (the consumption of iron need not exceed 1 lb. for each pound of copper precipitated, provided the solutions are neutralized before precipitation) and finally electrolytic precipitation.

The vital factors governing electrolytic precipitation are cost of power, material for anodes, and interference of other metals.

The power required for deposition from clean copper sulphate solutions is about eight or ten times that required for refining purposes, or about 1 kw. per pound of copper deposited. The most economical current density is between 10 and 11 amperes per square foot and the voltage required is about 2 volts, although with magnetite anodes it is said a current density of 15 amperes can be used. With an average cost of electric power of not more than 1c. per kw. the power costs for this method of precipitation need not be prohibitive.

The anode material heretofore has been confined to lead or antimonial lead. Fused magnetite is now being tried and is said to be very satisfactory, although fragile and expensive. Its merits are yet to be demonstrated on a large scale. Lead anodes are gradually consumed, forming the peroxide of lead, which can be collected, reduced and used over again if necessary.

Interference of other metals has proved the chief stumbling block in most of the attempts to use the electrolytic method for the recovery of copper. Arsenic and antimony are troublesome, but are seldom found in appreciable quantities in leachable ores. Iron is the principal source of trouble and with it may be considered manganese if present, for its influence is substantially the same as iron. Iron, by its alternate oxidation and reduction, consumes electrical energy without the deposition of copper. It must, therefore, be rendered innocuous by one of the following methods: Removal by precipitation, the use of diaphragms, or the use of depolarizers.

The first two methods seem impractical, but the use of a depolarizer seems to offer a way out of this difficulty. The most feasible depolarizer and perhaps the only one sufficiently cheap for this purpose is sulphur dioxide. This has some advantages and some serious disadvantages. Theoretically, sulphur dioxide used in this manner will regenerate 3 lb. of acid for each pound of copper deposited. In experimental practice, 2 lb. has been the maximum obtained, owing to difficulties of manipulation. A certain amount of electromotive force is also generated in the direction of the current used, which reduces power consumption. These advantages, however, are more apparent than real.

If much iron and alumina pass into solution from the ore, the actual acid regenerated in the electrolytic cells is relatively too small to be of any importance. On these Ajo ores, granting the best possible regeneration of acid from electrolytic cells, the author estimated that 75 per cent. of the acid used will have to be made in an acid plant. In actual practice it would no doubt exceed this amount.

The mechanical difficulties in making the copper lixiviums absorb sufficient sulphur dioxide gas to produce the desired results have not been solved. Introduction of the gas into the electrolytic cells at the anode secures a very small absorption and renders the electrolytic plant uninhabitable for human beings. Acid makers of experience do not offer much hope of success for absorption of this gas by means of scrubbing towers.

Those who have tried to make sulphur dioxide act as a depolarizer on a commercial scale report these claims a fallacy.

Moreover, it has been found that when electrolytes containing sulphur dioxide are used the current density must be reduced to the neighborhood of 3 amperes per square foot in order to get a satisfactory deposition of the copper. This means an electrolytic plant installation three times the size ordinarily required.

It has been found impracticable to deposit copper from electrolytes containing less than 1 per cent. copper. The average lixivium including enough wash water and acid to maintain a standard electrolyte will average between 1.5 and 2 per cent. copper. Assuming then, for the sake of argument, that 35 to 50 per cent. of the copper can be deposited in good form by electrolysis (35 per cent. is actually the case in the only plant in operation), if relatively large quantities of iron and alumina pass into solution at each cycle of the lixiviant it will be necessary to discard the entire lixiviant in a short time or a portion of it at each cycle, in which the copper will have to precipitated by a chemical reagent. This discarded lixivium will either be strongly acid, or, if neutralized by fresh ore, will carry its full quota of copper. In any leaching operation, there will be also a gradual accumulation of wash water or weak solutions, which will have to be treated with a chemical precipitant.

The conditions governing the successful deposition of copper from solution by electrolysis have been determined quite conclusively after long and careful experimentation by men skilled in the art.

With ores that will yield lixiviums free from interfering elements this method will no doubt prove a commercial success in spite of its expensive installation, but with ores like these where the iron passes into solution as readily as the copper, when the raw ore is leached with acid, it is almost a mathematical certainty that electrolytic precipitation cannot be made a commercial success and further experimentation along this line is useless.

A much more feasible method of overcoming this difficulty with iron would be to keep it from going into solution in the first place. This might be done by roasting the ore after crushing to the size required for leaching. The expense would be small. While there might be some danger of forming insoluble ferrites of copper, the iron and alumina would be rendered relatively insoluble in acid, the ore would be made more porous for leaching, there would be no argillaceous slimes to absorb valuable constituents, the copper sulphides and cuprite would be rendered soluble and the lixiviums might be clean enough for electrolysis.

The author's work was finished before this was tried.

### Slime-Concentrating Plant at Anaconda

The paper by **Frederick Laist** and **Albert F. Wiggin** describes the new slime-concentrating plant at the Washoe Reduction Works, Anaconda, put into operation during March, 1914. This plant, which has a capacity of 26,000,000 gallons of slime pulp carrying 2,500 tons of solid matter per day, consists of Dorr thickeners and Anaconda multiple-deck slime concentrators. This plant is the culmination of a great deal of experimental work extending over a considerable period of time. This work is described in the paper.

The authors discuss the sources and amount of slime and its composition and then describe the experimental development work at Great Falls and Anaconda. These experiments related to slime thickening devices, slime-concentrators, dewatering of the slime-plant concentrate, the use of chemicals to accelerate the settlement of slime, and the effect of temperature upon the settlement of slime.

Finally a description of the Anaconda slime plant is given. The plant consists of three divisions, the slime-thickening division, the concentrating division, and the concentrate-dewatering division.

### Chloridizing Leaching at Park City

The paper by **Theodore P. Holt** describes the plant of the Mines Operating Company at Park City, Utah, which was designed to treat the low-grade fillings in the old stopes of the Ontario mines. These fillings carry 6 to 14 oz. of silver, 1 to 2 lb. copper, 0.01 to 0.015 oz. of gold, and a small percentage of lead and zinc. The treatment consists in mixing the crushed ore with coal dust and salt and then roasting in a new type of furnace by combustion of the contained fuel. The roasted ore is leached with an acid salt solution to dissolve the silver, gold, copper, and lead. At present these metals are precipitated together on scrap iron and the product sold to a refinery.

The only new feature of importance in this scheme of treatment is the roasting process, which makes possible the chloridizing of ores without any loss of the valuable metals, and at a very low cost.

A paper by **James C. Ray** on microscopic study of Butte ores was finally presented and illustrated with stereopticon views.

### Tuesday

On Tuesday the members were taken by a special train to the Bingham mines of the Utah Copper Company. The Bureau of Mines' rescue car was attached to the train for inspection. A rescue demonstration followed the visit to the Magna mill.

The Garfield smelter was next visited, where the reverberatory furnaces fired by oil and coal dust, and the nearly finished Cottrell electrostatic precipitation plant for converter fumes were of special interest.

In the evening session William Wraith presided, and the following papers were presented in the smelting symposium:

W. H. Howard, "Electric Fume Precipitation at Garfield."

L. D. Anderson, "Effects of the Bag House on the Metallurgy of Lead."

Lawrence Addicks, "Nodulizing Blast-Furnace Flue Dust."

E. L. Newhouse, "Lead Smelting at East Helena, Montana."

W. W. Norton, "A Comparison of the Huntington-Heberlein and Dwight-Lloyd Processes."

G. P. Hulst, "The International Lead Refining Plant."

On account of limitations of space, abstracts of these papers must be reserved for our next issue.

A complimentary smoker at the University Club followed the session.

### Wednesday

On Wednesday the party was taken by a special train to the smelters at Murray, Midvale, and Tooele, Utah.

At the technical session in the evening C. W. Whitley presided. The subject was a symposium on zinc. The following papers were presented:

Dorsey A. Lyon and S. S. Arentz, "Losses of Zinc in Mining, Milling and Smelting."

R. D. Divine, "Separation of Lead, Zinc and Antimony Oxides.

S. E. Bretherton, "Treatment of Complex Ores."

H. A. Wentworth, "Electrostatic Separation at Midvale."

Earl T. Bardwell, "Effect of Annealing Upon Refined Copper."

C. D. Demond, "Economy and Efficiency in Reverberatory Smelting."

E. Horton Jones, "Unit Construction Costs for the New Arizona Copper Company Smelting Plant."

Dorsey A. Lyon and Robert M. Keeney, "Melting of Cathode Copper in the Electric Furnace."

C. R. Kuzell and I. H. Wigton, "Curves for the Sensible Heat Capacity of Furnace Gases."

L. O. Howard, "Basic Lines Converter Practice at the Old Dominion Plant."

On account of limitation of space abstracts of these papers must be reserved for later issues.

### Thursday

At the Thursday morning session Sidney J. Jennings presided, and the following papers were presented:

John Van N. Dorr, "The Dorr Hydrometallurgical Apparatus."

G. H. Clevenger, "The Mill and Metallurgical Practice of the Nipissing Mining Company.

Robert H. Bedford and William Hague, "Tests of Rock Drills at North Star Mine, California."

E. D. Gardner, "Mining Claims Within the National Forest."

A large party made an excursion to Park City, where the Mines Operating Company's plant was visited, in which low silver ores are chloridized as described in the paper of T. P. Holt, noted above.

### Banquet

On Friday night a banquet was held in the grill room, instead of the roof garden, of the Hotel Utah. It was a brilliant social event, graced by the presence of many ladies. Dancing followed.

The total attendance was about three hundred. W. L. Saunders acted as toastmaster, and speeches were made by President B. B. Thayer on "The American Institute of Mining Engineers," Bradley Stoughton on "Institute Ideals," Governor William Spry on "Utah," and E. M. Allison on "The General State of Affairs."

The whole meeting was most successful. Salt Lake City is wonderfully situated for such a convention on account of the great variety of mining and metallurgical operations, many of them being conducted on a tremendous scale. The hospitality of the Utah members was overwhelming.

## Synopsis of Recent Chemical and Metallurgical Literature

### Iron and Steel

**Finishing Temperatures and Properties of Rails.**—The main objects of an investigation recently completed by the Bureau of Standards, Department of Commerce, into the finishing temperatures and properties of rails were to determine, from measurements taken in representative rail mills, the present American practice regarding the temperatures at which rails are rolled; to demonstrate the ease and accuracy with which such temperatures may be measured; to find out what the "shrinkage clause" in rail specifications really means; and finally to determine for rail steels some of the physical properties, particularly those of interest in manufacture. Observations were taken with an optical pyrometer of ingot and finishing temperatures of rails in four representative mills. There is practical uniformity among the several mills for the rolling temperatures of ingots for steel rails, the range being from 1080° C. (1975° F.) to 1140° C. (2085° F.). There is no very considerable difference among the finishing temperatures of the rails as observed at the hot saws for the several mills, the range being about 880° C. (1615° F.) to 990° C. (1815° F.). Or, in other words, the four mills all finished their rails to within 50° C. of 935° C. (1715° F.) on the average. This temperature of 935° C. is 270° C. (520° F.) above the mean value, 665° C. (1230° F.) of the critical ranges of these rail steels. Concerning the distribution of temperatures within the head of a cooling rail, it is shown that the center of the head is some 50° C. (120° F.) to 60° C. hotter than the optical pyrometer reading at 935° C., therefore the center of the head is finished on the average at about 325° C. (615° F.) above the critical range for 100-lb. sections.

Chemical analyses and microphotographic examinations were also made and the mechanical properties determined for a number of samples of rail, the rolling of which had been observed. From a comparison of these few observations, there appears to be not a sufficient degree of correlation to warrant associating very specifically any of the characteristics defined by these three methods of examination, either with the temperatures of rolling here observed or with each other. The following thermal properties of these rail steels were determined in the laboratory:

The critical range on heating is located (maximum) to within 7° C. of 732° C. (1350° F.) for the 10 samples of open-hearth and Bessemer steels examined. On cooling the critical range lies between the limits 680° C. (1256° F.) and 650° (1202° F.).

The melting or freezing range for rail steel extends from about 1470° C. (2680° F.) to nearly the melting point of iron, located at 1530° C. (2786° F.).

The expansion for open-hearth and Bessemer steels is not the same. Above 800° C. (1470° F.) the expansion for both increases linearly with temperature and the linear coefficient per degree centigrade has the following mean values between 0° and 1000° C.

(1) For Bessemer steel (carbon .40 to .50%): alpha = 0.0000146.

(2) For open-hearth steel (carbon .65 to .70%): alpha = 0.0000156 to 0.0000161.

The average composition of the Bessemers was carbon = 0.40 to 0.50 and manganese = 0.76 to 0.93; of the open hearths, carbon = 0.66 to 0.70 and manganese = 0.66 to 0.72.

The American Society for Testing Materials in 1909 limited the shrinkage allowance on 100-pound sections to 6¾ inches in 33 feet, or to an equivalent of 1947° F. (1064° C.) for O. H. and 2055° F. (1134° C.) for Bessemer rails. This specification is still in force. Such a shrinkage clause therefore does not serve the avowed purpose of limiting the finishing temperatures to a value slightly above the critical range.

In conclusion, it should be emphasized that the various series of observations recorded in this investigation are of but a preliminary nature and do not pretend to solve the question of the relations between temperature of rolling and the properties of rails. It would seem desirable to make a much more complete and comprehensive study of the various matters mentioned and of related questions than has hitherto been attempted, and on a scale commensurate with the importance to the community of the problem of sound rails.

### Alloys

**Bronze.**—In his recent paper before the (British) Institute of Metals, Mr. **John Dewrance** draws attention to the desirability of modifying the composition of bronze with the object of preserving its strength when used for high pressure and superheated steam. The paper gives the results of a large number of experiments which go to establish the fact that the addition of a half of one per cent of lead preserves the strength of the bronze up to 500 deg. and that without the lead bronze loses its strength at 350 deg. F. It is suggested that as lead has this effect it is probable that further investigation might prove that some other ingredient might preserve the strength of bronze at even a higher temperature. It is also shown that oxygen in bronze does not reduce the strength within practical limits.

**Vanadium in Brass.**—In a recent paper before the (British) Institute of Metals on the effect of vanadium on the constitution of brass containing 50 to 60 per cent copper, Messrs. **R. J. Dunn** and **O. F. Hudson**

describe experiments which were carried out with the object of ascertaining what, if any, was the effect of small quantities of vanadium on the constitution and structure of certain copper-zinc alloys, particularly with reference to the change which occurs at about 460 deg. C. in those brasses which contain the beta phase. A number of alloys containing small percentages of vanadium and inconsiderable quantities of impurities resulting from the reduction of pure vanadic acid by means of aluminium were tested thermally and microscopically. It was found that the critical point at 460 deg. C. was only slightly affected by vanadium, 1 per cent raising it not more than 10 deg. C. It was also found that the usual structure of brasses containing 50-60 per cent of copper is not greatly modified by the presence of small quantities of vanadium. Thus the observation of Carpenter that 1 per cent of vanadium causes the complete structural resolution of beta into alpha and gamma was not confirmed. Some of the alloys were subjected to prolonged annealing at temperatures just below 460 deg. C., and the conclusion arrived at was the vanadium to the extent of at least 1 per cent appears to have no influence on the structural stability of the beta constituent of the copper-zinc alloys. The authors also consider that if any structural resolution of beta into alpha and gamma follows the addition of cupro-vanadium to brass the result probably is due rather to the relatively large amounts of aluminium usually present in commercial samples than to the small percentage of vanadium remaining in the finished brass. In an appendix a brief description is given of the method of analysis adopted.

**Corrosion of Brasses.**—In a recent paper before the (British) Institute of Metals on the microchemistry of corrosion **Mr. Samuel Whyte** and **Dr. Cecil H. Desch** discuss the effect of electrolytic corrosion on the a-brasses of copper and zinc. The total corrosion is less than in the b-brasses, and there is less preferential removal of zinc. The alloy containing 1 per cent of tin is at first more corroded than a 70:30 brass, but as time goes on the corrosion is lessened, owing to the formation of a very tough layer of basic salts. The protective action of tin is attributed to this cause. One per cent of lead does not retard corrosion, as the residual coppery layer is very open in texture, but an alloy with 2 per cent of lead, (70:28:2) becomes covered with a very firmly adherent layer. This alloy was much less corroded than any of the others examined. Brass condenser tubes, corroded during service, have a structure which may be exactly reproduced by the application of an external electromotive force. This point is proved by photomicrographs. The apparent differences depend on the rate of corrosion and the supply of oxygen. When corrosion is slow and the oxygen supply abundant, the spongy layer of copper is converted into oxide as fast as it is formed, but otherwise a metallic dezincified layer remains.

**Nickel in Copper-Aluminium Alloys.**—In their recent paper before the (British) Institute of Metals **Professor A. A. Read** and **Mr. R. H. Greaves** discuss the influence of varying percentages of nickel on some mechanical and physical properties of the copper-aluminium alloys with 5 and 10 per cent of aluminium respectively. Hot rolling and forging tests showed that apart from increased hardness, and the necessity of a higher rolling temperature, the behavior on hot rolling of alloys with up to $7\frac{1}{2}$ per cent of nicked was identical with that of the pure copper-aluminium alloys. Malleability and ductility are rapidly reduced by nickel in the 10 per cent aluminium series, but with 5 per cent of aluminium the presence of nickel increased the ductility as judged by the wire drawing tests. The main features of the tensile, hardness and alternating stress tests considered in conjunction with the microstructure may be stated briefly as follows:

(1) Alloys with 10 Per Cent of Aluminium.—Nickel up to 10 per cent in the chill castings gives increased maximum stress and yield point at the expense of elongation and reduction of area: 5 per cent of nickel gives maximum hardness; 5 per cent of nickel improves the annealed metal and diminishes the detrimental effect of annealing on the 10 per cent aluminium alloy. This composition corresponds to the limit of the alpha plus beta structure, increase of nickel above 5 per cent being accompanied by the separation of a blue constituent in place of beta. The effect of quenching on these alloys is similar to that on the 10 per cent aluminium bronze, but becomes less marked as the nickel increases.

(2) Alloys with 5 Per Cent of Aluminium.—Both in the chill castings and annealed rods, nickel has little effect on the hardness, maximum stress and yield point until 5 per cent is present. The ductility, however, is greatly increased by 1 per cent of nickel. With less than 5 per cent of nickel, the alloys consist of a homogeneous solid solution; with more than 5 per cent a second constituent separates on slow cooling, causing in the annealed rods a rapid increase in hardness, maximum stress and yield point with an accompanying diminution in elongation and reduction of area. The effect of quenching on the alloys with 5 per cent of nickel and over is to retain the second constituent in solid solution and thus to increase the ductility, while the hardness, maximum stress and yield point diminish. The rate of cooling need not be very great, for air-cooled rods gave results which approximate to those of the quenched.

The presence of nickel makes practically no difference to the specific gravity of these alloys: their melting points are raised, and conductivity for electricity greatly diminished. Corrosion by sea water is greatly reduced by the presence of nickel: there is no difference in behavior between the annealed and cold rolled metal. All the alloys with 5 and 10 per cent of aluminium and varying nickel behaved better both in fresh and sea water than either Muntz metal or naval brass.

**Rapid Cooling of Binary Alloys.**—Before the recent meeting of the (British) Institute of Metals **Mr. G. H. Gulliver** presented a paper which was a continuation of one read before the Institute last March. The methods then explained were now extended, so that the proportions of the constituents of a rapidly cooled binary alloy could be determined with a close degree of approximation whatever the curvature of liquidus and solidus. Results were given for the more important alloys of the copper-tin and the copper-zinc series, and for the copper-nickel series. A formula was devised for calculating the proportions of the constituents obtained with moderate rates of cooling when the liquidus and solidus are sensibly straight, and the results obtained from this for the lead-tin series were given.

**Solidification of Metals from the Liquid State.**—At the recent meeting of the (British) Institute of Metals **Dr. Cecil H. Desch** presented his first report on this subject to the Beilby Price Committee. The arrangement of crystal grains in a metal or alloy has usually been accounted for by growth of crystallites from independent centers. Against this, Quincke has proposed the hypothesis of foam-cells. On this view, the liquid separates immediately before crystallizing, into two liquids, which arrange themselves to form a foam, and crystallization then takes place within the foam-cells. Quincke has applied the hypothesis to the explanation of many of the properties of metals. Several recent writers have also sought to connect the cellular structure with the prismatic partitioning of cooling liquids by convection currents. Whilst this arrangement may possibly be traced in some metals when cast in thin sheets, it cannot account for the structure of ingots or other large masses. The passage of metals in certain cases through an intermediate liquid-crystalline state has also been assumed, but not yet established. A review of the existing evidence suggests that several distinct cellular structures have often been confounded, and that a common origin has been assumed for structures which have a merely geometrical similarity.

The effect of undercooling, and the possibility of existence of two distinct classes of undercooled liquids is also discussed, as well as the changes of volume which occur during fusion and solidification. The determination of such changes is shown to be complicated by other factors, so that an increase in the external dimensions of a casting does not invariably represent an actual increase in the volume of metal. Lastly, the programme of experimental work now in progress, with the object of testing and comparing the hypotheses mentioned above, is briefly outlined.

**Muntz Metal.**—At the recent meeting of the (British) Institute of Metals Dr. J. E. Stead and Mr. H. G. A. Stedman presented a paper on the correlation of composition heat, heat treatment, structure and mechanical properties of Muntz metal. The authors having obtained a set of ½-in. bars of pure Muntz metal for the purpose of the research, heated them in duplicate in a tube furnace electrically heated for 48 hours to various temperatures ranging between about 500 deg. C. and 860 deg. C., after which treatment one of the heated bars, in each set, was quenched in cold water, the companion bar being allowed to cool in air. The cold bars were then examined microscopically and tested mechanically. Other bars were heated for three months at about 430 deg. C., and at 270 deg. C. for 984 hours and they were also tested and examined. The results appeared to dispose of the idea, held in some quarters, that Muntz metal could be burnt by high heating, and that quenching tended to soften brass, for while the annealed metal cooled in air had a tenacity of about 25 tons, the same material quenched from 812 deg. C. had a tenacity of 29½ tons—an increase of about 4½ tons.

The practical importance of the research is undoubted, as it shows:

First—That Muntz metal should not be annealed at temperatures between 750 deg. C. and 800 deg. C., as this is a range of danger, but it may be heated above 800 deg. C. without destroying its good quality.

Second—That it is made homogeneous and can be hardened to a considerable degree by heating to and quenching from above 800 deg. C.

Third—That the maximum degree of softness is obtained by long heating at the temperature of melting zinc—about 430 deg. C.

Fourth—That Muntz metal is very slightly oxidized by annealing even at 800 deg. C., and that the scale produced on the surface consists of zinc oxide free from copper.

The final part of the paper is devoted to the description of methods of tinting brasses so as to reveal their structure, and to the effect of hard drawing in leading to fractures in Muntz metal during service.

**Report of Committee on Nomenclature of Alloys.**—At the recent annual meeting of the (British) Institute of Metals in London the committee, consisting of representatives of the Institute of Metals, the Institution of Mechanical Engineers, the Institution of Electrical Engineers, the Institution of Naval Architects, the Institution of Engineers and Shipbuilders in Scotland, the North-East Coast Institution of Engineers and Shipbuilders and the Society of Chemical Industry, (chairman, Dr. W. Rosenhain, F.R.S.), present a unanimous report in which they recommend the adoption, first of a systematic nomenclature in which alloys are denoted by the names of their constituent metals in English, arranged in increasing order of percentage present in the alloys. This systematic nomenclature is intended chiefly for scientific and other purposes where its precise character more than outweighs its cumbrousness. The committee next recommends that a system of "practical" nomenclature should be set up consisting of "practical" names which are to serve as every-day abbreviations of the systematic or scientific names. The definition of current practical names on this basis has so far only been attempted in regard to the two important terms, "brass" and "bronze." The definition of "brass" adopted by the committee is that it is to be used as an abbreviation of the words "zinc-copper" as employed in the systematic nomenclature; when employed alone it indicates that the alloys are pure zinc-copper. Where the presence of other metals is to be indicated their names are to be prefixed to the term, forming such words as tin-brass, aluminium-brass, manganese-brass, etc. Similarly the term "bronze" is defined as an abbreviation for "tin-copper" as used in the systematic nomenclature, the definitions in other respects being identical as that for "brass." The committee is not yet prepared to recommend definitions of further practical terms, but the two terms defined represent the most widely used alloys, and their general adoption as thus defined would do much to remedy the state of confusion which exists at the present time. The committee, therefore, appeal to all those interested in the progress of the industries and sciences connected with metals to use their best endeavors to support and carry out the recommendations of the committee.

## Oils

**Iodine Number of Linseed and Petroleum Oils.**—The determination of the iodine number of linseed and petroleum oils according to the Hanus method has just been completed by the Bureau of Standards of the Department of Commerce and the results published in Technologic Paper Number 37. Each of the three factors, weight of sample, time of absorption, and amount of Hanus solution was studied for a series of burnt linseed oils and petroleum oils. The results produced by variation of one of the factors, the others remaining constant, are reproduced graphically. Variations of weight of the raw linseed oil show that a constant volume is obtained for weights of the oil up to 0.25 gram. Beyond this value, the iodine number decreases with increasing weight. For burnt linseed oils, the range of weight over which the iodine value is constant, decreases with increased burning of the oil. Petroleum oils, on the contrary, approach a constant value when 0.6 gram or more of the sample is taken. Varying the time of absorption from five to sixty minutes shows that the reaction approaches a maximum in about ten minutes. Thereafter, absorption is slow, and a few minutes one way or another has little effect on the value obtained. When the amount of Hanus solution is varied from 20 to 75 cc. the results indicate that the oil with the highest iodine number does not require the greatest excess of iodine to reach maximum absorption value. The effect of temperature on the value obtained is more marked for burnt linseed oils than for boiled or raw oils. The results as a whole indicate that concordance is obtained only when a prescribed procedure is followed with exactness. To obtain comparable results, a standard procedure should be followed in which the limits are strictly defined. This is particularly true of burnt linseed oils.

---

## Notes on Chemistry and Metallurgy in Great Britain

*(By our Special Correspondent)*

### Electric Mains Explosions

Last December the Board of Trade appointed a departmental committee to investigate the causes of explosions which were connected with cables laid in bitumen or sheathed with vulcanized bitumen at Hebburn, Nottingham and various other places. The report of this committee has recently been issued; and it appears that no serious cases of explosions have been disclosed nor was there any proof of instances where the supply was furnished by alternating current, by concentric mains, or by lead-covered paper-insulated cables, including three-core cables.

The faults occurred with single-core separate cables, sheathed with india rubber, or with vulcanized bitumen. And in all the cases of serious explosions which occurred in houses the cables were insulated with vulcanized bitumen; and such cables had either been drawn into bitumen casing or laid in bitumen on the solid system in troughs. Three causes of the deterioration of vulcanized bitumen are pointed out by the committee: (1) softening of the sheathing caused by coal gas; (2) corrosion of a conductor, consequent on a fault in a positive; and (3) faults to earth in a negative.

In the third class the conductor is not attached, but the insulating material is decomposed. Infiltration of moisture and osmosis render the bitumen pulpy and ultimately leakage occurs between positive and negative, or between middle and negative on the three-wire system, with the result that a short circuit is set up. When the resistance of the cable is sufficiently high the heat may only suffice to melt the adjacent bitumen which flows in, quenches the arc and seals the fault; but should the arc be persistent both the vulcanized bitumen sheathing and the trough bitumen would be melted and ultimately decomposed into gases which would form explosive mixtures with air.

However, the proportion of accidents which have occurred with vulcanized bitumen cables laid in solid bitumen has been so small in relation to the very large number of such cables in use that the committee is not prepared to recommend that approval of such system be discontinued. But the committee has arrived at the conclusion that the view that serious explosions are not likely to occur when pitch compound is used instead of bitumen for filling the troughs is justifiable. The committee is not able to recommend the exclusion of wood troughing in favor of iron or stoneware troughing, but does recommend the use of wooden troughing should be restricted to suitable soils.

In cases where separate mains are laid in troughing every cable should be laid in a separate trough; and there should be a space of not less than 2 in., tightly packed with earth or sand, between each trough. Separate mains for the supply of continuous current on the solid system should not be laid below pavement or close to the walls of houses; the bends at corners should be easy and the bitumen or pitch compound should be poured after the straight lengths have cooled.

With regard to the existing mains it is recommended that in all suspected cases of sharp corners the mains should be taken up and the corners eased, and that the service cables should be led into the houses in such a way as to preclude the possibility of the entrance of gas. Finally the committee recommend that the attention of engineers should be directed to the clauses of the Electric Lighting Act, 1899, and the Board of Trade regulations which enjoin notification of accidents by explosions or fire.

### The Effect of Temperature on the Properties of Gun Metal

At the recent Conference of Shipbuilders and Engineers at Newcastle Prof. J. G. Longbottom and Prof. A. Campion contributed a paper on the influence of varying temperature on Admiralty gunmetal. The metal used for the whole of the experiments was composed of 87.96 per cent of copper, 9.77 per cent of tin, 1.94 per cent of zinc, 0.18 per cent of lead, and 0.13 per cent of iron.

Two sets of tests were made. In the first cast bars 15 in. long were cut into lengths of 7.5 in., screwed with 7/8 Whitworth thread on the ends and turned down in the middle for a length of 3.5 in. to a diameter of 0.564 in.; while for the second set cast bars about 10 in. long were screwed with 1 1/8-in. thread for 2 in. at each end and turned down to a diameter of 0.798 in. for a length of about 5.5 in. in the middle.

During the tests the gunmetal bars with about 6 in. of each of the tension rods were placed in the center of an electric resistance furnace the temperature of which was taken with three platinum-iridium thermocouples. The results of the first series of tests showed very little change of strength from the initial temperature up to about 200 deg. C.; and, while the results from 200 deg. to 250 deg. were rather irregular, there was general indication of decrease of strength. As the temperature was further raised the strength continued to fall, until at 750 deg. there was practically none. At first there was an appearance of a slight increase of elongation with the increase of temperature, touching the maximum at 140 deg. C. As the temperature rose, however, it quickly fell, and at 350 deg. C. was less than 1.5 per cent. Thence up to 500 deg. there was but little alteration, with a slight tendency to an increase at about 400 deg. The modulus of elasticity was practically unaffected up to 200 deg., but diminished continuously with a further rise of temperature.

The second series of tests showed very little change in strength up to 200 deg., but above that point there was a steady continuous fall. Elongation and contraction of area both rose rapidly with the temperature, showing a maximum at 160 deg. for elongation, and at a slightly lower temperature for contraction. The ductility fell rapidly between 250 deg. and 350 deg. A sudden change in the direction of the curves occurred at about 350 deg. The modulus of elasticity showed similar variations to those in the first series.

The fact that the change in the direction of the curves uniformly occurred at the same temperatures appears to indicate that these temperatures are critical for the metal, and such change might therefore be attributed to changes in the phase relationship of the metal; but so far no critical points have been established in thermal curves of similar alloys at the point at which the sudden changes in mechanical properties occurred in these experiments.

The authors therefore infer that the changes in mechanical properties are not related to phase changes in the alloy. They consider that their results are strong evidence of the existence of some kind of cement between the crystalline particles of the metal. At certain temperatures marked slips occur after the yield point is passed, not only with nonferrous metals but also with steel; and sometimes these slips are of such extent that the steelyard falls on the bottom stop as if fracture of the specimen had occurred. But after a short interval the metal recovers and bears a further load.

The authors are of opinion that this phenomenon may be explained by the amorphous cement recrystallizing and causing a reduction of adhesion between the crystals of the metal sufficient to permit some of those crystals to separate from their neighbors under the stress, while actual rupture is prevented by the friction of the crystal faces against each other under sufficient pressure to re-form a quantity of the cement into an amorphous condition, thus partly restoring adhesion.

The reconstituted amorphous material becomes again crystalline by the influence of heat and another slip occurs; so that there are alternate transformations into crystalline and amorphous material, with corresponding decreases and increases of strength. Moreover, during the latter series of tests an appreciable increase in temperature of the gunmetal was observed immediately after each slip; and this is just what might be expected as the result of the recrystallization of the amorphous cement.

### The Strength of Oxy-Acetylene Welds

The same Conference of Shipbuilders and Engineers also brought forth a paper by Prof. A. Campion and Mr. Wm. C. Grey which gave the results of tensile and impact tests of oxy-acetylene welds. The authors remarked that under working conditions the material was usually subjected to repeated shocks; and they had, in addition to static tests, compared the effects of repeated impact on welded and unwelded metal. The material used was mild steel containing about 0.25 per cent of carbon. For the first series bars ⅝ in. in diameter were turned down for a length of 1½ in. at the weld to ⅜ in. in diameter, the elongation being taken on a 1-in. length. Contraction of area was not recorded because most of the fractures were too ragged to allow of measurement. The results indicated that an average weld would have about four-fifths of the strength of unwelded steel, while the ductility would be only about one-fifth. There was no great variation in maximum tensile strength, but ductility varied widely from the average; for, the lowest strength of welded metal was about 80 per cent of that of the original steel, and the lowest elongation was only 9 per cent.

Ductility was increased by hammering; but the strength was lowered. Reheating after hammering improved both the ductility and the maximum stress. Reheating at the same temperature without hammering caused a comparatively large rise in ductility and a small rise in the strength. Quenching in water and reheating brought the strength up almost to that of the unwelded steel but diminished the elongation.

For the impact tests bars 6¼ in. long and ½ in. in diameter were notched in the center of the welded part to a diameter of 0.4 in. The results again showed great variation, and suggested that an average weld would resist only half as much fatigue as unwelded metal. Hammering improves the weld in this respect, but the metal should be reheated at a full red heat—800 deg. C.—to avoid production of strains or brittleness. Reheating or annealing without hammering has but little effect. The treatment which produced the best results in the tensile tests gave the worst in the impact tests.

Further experiments with the bars notched at the edge of the weld instead of at the center were made to ascertain the influence on the whole weld of the overheated zone produced during welding, and the results varied still more than those given by centrally notched bars; but while the hammered specimens of the latter gave 84.4 per cent of the original strength the hammered side-notched bars gave only 57.7 per cent. Impact tests on plates of different thicknesses showed conclusively that the reliability of the weld and the strength decreased as the thickness increased.

The authors conclude that very serious responsibility is incurred by using autogenous welding in parts which may be subjected to any considerable strain.

### Iron and Steel Alloys

Sir Robert Hadfield, in his presidential address to the Faraday Society, remarked that Faraday did a great deal of pioneer work in researches connected with the alloys of steel. He was of opinion, however, that research work on the compounds of iron and carbon had not been sufficiently followed up; and to emphasize the importance with which he regarded such work he offered two prizes of £200 each to the Iron and Steel Institute and to the American Institute of Mining Engineers for the best paper or research on the subject.

Metallurgists were now speaking of carbides, subcarbides, double-carbides and other compounds, but it was most desirable that those substances should be thoroughly investigated and defined. Moreover it was desirable to ascertain the state in which the carbon existed. A certain form of carbon in iron and steel was referred to as a "missing" form, and but little is understood about it; and more information about this form of carbon is required because it was desirable to know whether the carbon not determined as a carbide is "missed" because of its existing in an extremely fine state of division or whether it is in some special form of combination.

With regard to the alloys of iron with elements other than carbon, the fact that in such steel carbon holds a position of supreme importance should not be lost sight of; for with few exceptions its presence in these special alloys was indispensable. For example, in high-speed tool steel, although the carbon content need not be relatively high, yet it must be great enough to ensure the cutting properties of the steel being attained.

As a probable explanation he mentioned that in modern high-speed tool steel there is generally 16 to 20 per cent of tungsten and 2 to 4 per cent of chromium and about 0.74 per cent carbon. Previous to heat treatment the carbon exists in the steel both as carbide and as hardening carbon as defined by Ledebur—0.56 per cent of the former and 0.18 per cent of the latter; but after heat treatment and when the cutting edge of the tool had been brought to the requisite condition, the hardening carbon amounted to 0.6 per cent and the carbide carbon to 0.14 per cent. Consequently the effect of the addition of elements other than carbon must be regarded as entirely due to the change brought about by heat treatment in the form in which the carbon exists by converting it from carbide carbon into what is termed hardenite; and the elements employed as alloys enabled the hardening carbon to retain its properties in a cutting steel. Heat treatment produced a similar change in any low-carbon steel which did not contain other elements except, perhaps, in very small quantities; but the tungsten and chromium in high-speed steel appear to help to maintain the hardenite as hardenite, and consequently the cutting edge did not lose its hardness, even when the friction caused very considerable rise of temperature, such as would soften ordinary steel.

In 1903 he carried out experiments with two kinds of steel, both of which contained similar quantities of chromium and tungsten, but one had a carbon content of 0.35 per cent and the other a carbon content of 0.74 per cent. They were both subjected to heat treatment at 1100 deg. C. and cooled in air, when the steel with the higher carbon content contained 6.6 per cent of hardenite and was an excellent tool steel. The other sample contained practically no hardenite; almost all the carbon existed as carbide; the metal was soft, would not carry a cutting edge and was useless as tool steel.

The importance of investigating the alloys of iron was not to be measured merely from the point of view of getting the exact combination required for any purpose, but also by obtaining the maximum degree of utility from a given quantity of metal. A pound of alloy tool steel would go as far as many pounds of ordinary metal, and although the former was more expensive it was really a saving.

In the United States some 33,000,000 tons of pig iron were now being produced per annum; Germany turned out about 20,000,000 tons, whilst the total output of Britain, France and Belgium amounted to nearly as much more. This enormous consumption of iron ore could not be maintained indefinitely, and we might probably before long find it desirable to husband our resources of iron ore more carefully than we did at present.

Great Britain had now gone down to the third place among the nations in the production of pig iron, but we were more prosperous than ever, and the tonnage production was, therefore, not a decisive index so long as we could maintain a cheap supply of ore, pig or bar iron. But of course the most important point was the provision of the requisite supply of ore. Henri Gaston pointed out in his "Ou va l'Allemagne?" that Germany will shortly exhaust her own supplies of ore and does not control any outside sources of notable value. M. Gaston claims that the metallurgical future of France will be much greater, and he says "We are destined, if nothing happens to counteract our designs, to become the most powerful metallurgical nation in the world."

### The National Physical Laboratory

The annual meeting of the general board was held on Friday, June 19, under the presidency of Sir William Crookes. The work and equipment of the laboratory have made great progress during the past year, and the total value of the goods represented by the materials tested was approximately £300,000. The research carried out by Mr. F. E. Smith on the absolute measurement of the standard of electrical resistance resulted in his finding that the international ohm is equivalent to 1.00052 x 109 C. G. S. units of resistance, or, in other words, the length of the mercury column representing the true ohm should be 106.245 cm., instead of 106.3 cm.

The total income of the laboratory for the year 1913-14 was £43,713 as against £32,058 in the preceding year, and the respective expenditures were £40,968 and £32,479. Consequently the year under review showd a credit balance of £2,745, whilst in 1912 there was a deficit of £420. The experimental tank building fund was deficient to the extent of £2,661, and part of the general balance would be applied to the reduction of this debt.

No doubt from the point of view of the directors of the National Physical Laboratory the increase in their income is very satisfactory; but, having regard to the fact that that increase of income is largely derived from a further diversion of work from professional men in private practice, it is doubtful whether the leading scientific and technical societies will look on the matter with the same degree of satisfaction. The national purse will provide the N. P. L. with all the funds requisite for the carrying out of its legitimate work; and there is no necessity for its entering into competition with the chemist, the metallurgist, the engneer and the electrician.

### Humphrey Pumps for the Egyptian Irrigation Department

The level of Lake Mariut, into which the drainage of the Behira district should flow, has become so much raised that it is no longer possible for the water to adequately make its way into the lake, which has a depth of only about 3 ft. with an area of some 50,000 acres, and which is divided from the Mediterranean Sea by a narrow strip of land having an elevation of 20 ft. or less above the surface of the lake. It has been decided to erect a pumping station at Mex, near Alexandria, for the purpose of discharging into the sea the water from a large canal which is now being cut through the dake. The first installment of the plant will consist of ten Humphrey pumps capable collectively of delivering 980,000,000 of gallons of water in 24 hours, with a lift of about 20 ft.; but two pumps will be kept in reserve. It is proposed to add another set of ten similar pumps afterward. The combustion chambers of these pumps will have a maximum diameter of 8 ft. 8 in. and a height of nearly 14 ft., while the water valve boxes will have only half that height with the same diameter, and will each be furnished with 100 hinged valves of new design. Each of these pumps will have about two and a half times the capacity of the large Humphrey pumps at the Chingford station of the Metropolitan Water Board. They are being constructed by two British firms.

Power will be supplied from an anthracite Mond gas plant gassifying 44 tons per day with a guaranteed consumption of 1.15 lb. of coal per water horse-power.

An electric power and lighting plant will also be put down consisting of two 180-b.h.p. gas engines coupled directly to 120-kw generators supplying current at 220 volts.

### The Institute of Metals

### The Employment of Non-Ferrous Metals in the Navy

Sir Henry J. Oram, engineer-in-chief of the fleet, in the course of his presidential address to the institute, gave some very interesting figures relating to the amount of non-ferrous metals used in the construction of our battleships and cruisers at the present day as compared with 20 or 25 years ago.

At the present time for every hundred tons of iron and steel used in the construction of a battleship there were about six tons of copper or copper alloys, whilst in a cruiser the proportion of copper and its alloys amounted to eight tons. The higher proportion of non-ferrous metals used in the construction of a cruiser was owing to the smaller weight of armour carried and the increased power of the machinery which, of course, necessitated the employment of a proportionately greater amount of non-ferrous metals than did the hull and other structures.

With regard to the propelling machinery, the proportion of non-ferrous metals in a modern battleship was some 17 per cent of the steel and iron. Twenty years ago the corresponding proportion of non-ferrous metals was some 34 per cent.

The proportionate amount of non-ferous metals, however, had not been similarly reduced in the structure of the hull, and the greater increase in the employment of steel had been counterbalanced by the large increase of non-ferrous metals employed in gun turrets, controlling apparatus, electric lighting and so on, so that excluding the propelling machinery the whole structure of a battleship now contained about 4.4 per cent of non-ferrous metals in relation to the amount of iron and steel, as against 4.2 per cent 20 years ago.

A great deal of careful attention had been given to condenser tubes, which simple articles had an important effect on the reliability of the ship's machinery. Corrosion of condenser tubes constituted a very important defect but some of the worst troubles experienced in the navy have arisen not so much from corrosion or perforation as from splitting of the tubes whilst at work and although the total failures due to corrosion and perforation largely exceeded the number due to splitting, the consequences of the latter mishap were very much more serious. In the year 1908 there were approximately 2,500,000 condenser tubes in use at sea in the fleet, and the number of failures reported as having occurred on service were: splitting 21; corrosion and perforation 69; giving a total of 90, which was equal to one tube failing in 28,000 for the year.

The 1913 returns showed approximately 3,800,000 tubes in use, and the total number of failures reported as having occurred during the years 1912 and 1913 were: splitting 16; corrosion and perforation 115; giving a total of 131, which was equal to one in 60,000 per year, which figures showed a very satisfactory reduction.

### Company Meetings and Results

*John Brown & Co. Ltd.*—Lord Aberconway presided at the annual meeting on June 30, and remarked that he considered the balance sheet to be the best and strongest ever presented by the company. The balance amounted to £467,000; out of which, after paying the usual preference dividend and 10 per cent on the ordinary shares, £100,000 would be appropriated to extensions and £96,000 carried forward to next year's account.

*General Electric Co., Ltd.*—The ordinary general meeting was held on July 2, when Mr. Hugo Hirst presided. The net trading profit for the year was £157,893, and the total balance was £190,224. After due provision for depreciation, placing £30,000 to reserve account, and putting £14,000 toward the expenses of the recent increase of capital, this sufficed for a dividend of 10 per cent on the ordinary shares and to carry forward £36,739.

*Victoria Falls and Transvaal Power Co., Ltd.*—The annual general meeting took place on July 8 under the presidency of the Marquess of Winchester. For the year 1913 £467,823 were carried to appropriation account, £21,443 more than in the previous year. Interest on debentures absorbed £203,920; £135,491 were applied to depreciation, and £128,411 carried to credit of profit and loss account which showed a balance of £225,198, out of which dividends at the rate of 6 per cent per annum had been paid on the preference shares for the year 1912. The dividends amounted to £120,000, leaving £105,198 to the credit of profit and loss account as a reserve at the beginning of the year. It will be seen that the preference dividend is twelve months in arrear.

*Mond Nickel Co., Ltd.*—Sir Alfred Mond presided at the annual general meeting on July 6. A number of new properties had been acquired and developed during the year. The profit and loss account showed a balance of £297,000 against £232,000 for the previous year. After deducting the amount of the interim dividend on the preference shares the available balance was £284,000.

The directors proposed to pay the usual dividend on the preference shares, 35 per cent on the ordinary shares, a dividend of £79,000 on the deferred shares, and to carry forward £91,000.

*Brunner, Mond & Co., Ltd.:*

The report for the year ended March 31st shows a profit of £769,344. O. O. It is proposed to pay a dividend on the ordinary capital amounting, with the sum paid on December 12th, to $27\frac{1}{2}$ per cent for the year, less income tax. £2,500 O. O. is written off patents account and £110,921 O. O. is carried forward.

*The Bleachers' Association:*

The account for the year ending March 31st shows a net profit of £666,045 O. O., after placing £210,865 O. O. to repairs and maintenance account, £15,000 to leasehold and sundry property account and £60,000 to depreciation. £50,000 will be transferred to general reserve, £60,000 to reserve for equalization of dividends and £15,000 to fire insurance.

A dividend for the six months ended March 31st of 7 per cent on the ordinary shares is recommended, making 6 per cent for the year. £173,957 is carried forward.

### Market Prices

### *July*, 1914

| | £ s d |
|---|---|
| Aluminum, ingots, ton lots | 86. 0. 0 |
| Alum lump, loose, per ton | 5.10. 0 |
| Antimony, Star Regulus, ton | 26.10. 0 |
| Borax, British refined crystal, cwt | 17. 6 |
| Copper sulphate, ton | 20.10. 0 |
| Caustic soda, 70%, ton | 10. 0. 0 |
| Copper ore, 10% to 25%, unit | 10/4½ to 10.10½ |
| Ebonite rod, lb | 4. 6 |
| Hydrochloric acid, cwt | 5. 0 |
| India-rubber, Para, fine, lb | 2.10¼ |
| Mica, in original cases, medium | 3/— to 5. 0 |
| Petroleum, Russian spot, gal | 9¼ |
| Quicksilver (Spanish) bottle | 6.15. 0 |
| Sal-Ammoniac, cwt. | 2. 2. 0 |
| Sulphate of ammonia, ton | 11. 0. 0 |
| Sulphur, recovered, ton | 5.10. 0 |
| Shellac, cwt. | 3. 5. 0 |
| Platinum, Oz., nominal | 9. 5. 0 |
| Tin ore, 70%, ton | 92. 0. 0 |
| Zinc, Vielle Montagne | 25. 2. 6 |

*Copper* opened at £61 and rose till the 6th when it was £62 10s., then declined till the 10th to £61 7s. 6d., and recovered till the 17th £61 6s. 3d., but had again reached £61 by the 20th and £60 10s. by the 23d. It fell on the war news to £58 on the 28th and £57 on the 29th.

*Tin* opened £140 15s. and after a slight decline rose rapidly to £145 15s. on the 6th; after another slight decline it reached £147 5s. on the 9th. It then fell away to £142 17s. 6d. on the 15th, but had recovered to £145 17s. 6d. on the 20th.

On the 28th it was £135 10s. and on the 29th the same price.

*Haematite* opened at 61s. and remained steady at this price throughout the month.

*Scotch Pig* opened at 57s. and appreciated fairly steadily to 57s. 7½d. on the 8th and then dropped slightly, recovering to 57s. 6d. on the 14th and closes 57s. 3d.

*Cleveland* opened at 51s. and improved till the 8th when it was 57s. 7½d. It then declined a little, but recovered to 51s. 6d. on the 14th, afterward dropped to 51s. 4½d., remaining at this price till the 20th and closing lower, 51s. 1½d.

*Lead* opened £19 10s. and had risen to £19 15s. by the 6th and £20 by the 9th, but was weaker on the 13th, and had again fallen to £19 10s. by the 16th, keeping at this price till the 20th but afterward declining and reaching £19 5s. by the 28th.

### Differences in the Month

| *Higher* | £. s. d | *Lower* | £. s. d |
|---|---|---|---|
| Aluminium, ton | 1. 0. 0 | Antimony, ton | 0.10. 0 |
| Sulphate of ammonia | 10. 0 | Copper sulphate, ton | 10. 0 |
| | | Mica | 0. 6 |
| | | Quicksilver | 5. 0 |
| | | Tin, ton | 5 5. 0 |
| | | Copper, ton | 4. 0. 0 |

## Concentrating Unsized or Unclassified Ore-Pulp

A new ore-concentrating machine having the general appearance and mode of operation of a concentrating table, but acting more on the principle of a jig, is the Isbell concentrator, manufactured by the Denver Engineering Works Co., Denver, Colo. The device is a radical departure in concentrator construction, and embodies some novel features in its operation. Preliminary classification or sizing is dispensed with; there is no transverse current of wash water; concentrate pockets deliver the concentrate through the deck of the table, while tailing and middling pass over the end; the general movement of ore-pulp is coincident with the progressive motion of the table.

A view of the concentrator from the tail end is shown in Fig. 1. It consists of a riffled deck divided into two similar sections by a longitudinal partition, each section having a feed-box, riffles and six concentrate pockets which are supplied with hydraulic water from above. The deck is mounted on steel base-frame and steel spring supports, and carries the concentrate launders underneath. The drive imparts a differential reciprocating motion to the deck. The riffles converge from the edges of each section to the central line of concentrate pockets, and their use is mainly to direct the stratified concentrate to the pockets. A section through one of these pockets is shown in Fig. 2. In a measure it constitutes a classifier, inasmuch as the hydraulic water flowing against the entering stratum of concentrate effectually sorts and washes back any gangue particles that may be included.

The operation of the concentrator is unusually simple. Ore is ground to, say, 6-mesh, and without classification or sizing or removal of slime, is fed onto the reciprocating deck of the table with enough water to make the pulp flow readily. The motion of the deck causes the particles of pulp to stratify according to their relative specific gravities, and the heaviest mineral particles settle into the riffles, with the gangue lying above. As the pulp progresses along the deck the settled concentrate is directed by the riffles into one of the concentrate pockets where it encounters a light stream of water under pressure sufficient to wash back any gangue, while allowing the concentrate to enter and pass out through the discharge tube. Any valuable mineral that does not settle and pass into the first pocket is caught in one of those farther down the table. The gangue flows over the pockets. Finally, anything passing the last pocket is presumably either middling or tailing, and these are separated by the last set of riffles and divided on the tail board by means of adjustable partitions.

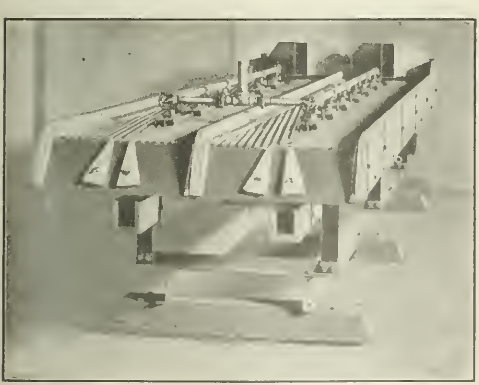


FIG. 1—ISBELL CONCENTRATOR

On a machine of this type the practice of treating an unsized or unclassified feed is not as unorthodox as it sounds. It is well known, for instance, that the motion usually appllied to a gold-pan filled with coarse and fine ore and water results in gathering all heavy mineral or metal in a bottom layer, irrespective of the size of those particles. Similarly, the Joplin jig treats an unsized product, with the result that practically all the free mineral settles through the pulp, the coarser particles being retained on the bed, while the fine pass through it into the hutch. In the same way the unsized pulp fed onto an Isbell concentrator becomes stratified, and all heavy particles, irrespective of size, accumulate in a bottom layer that is subsequently guided by the riffles into the pockets and discharged. By regulating the stream of hydraulic water entering the pockets, the concentrate may be discharged with a varying quantity of gangue.

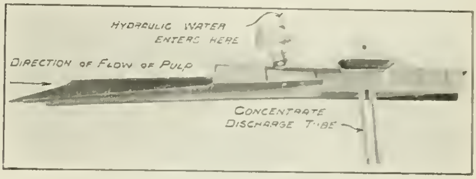

HYDRAULIC WATER ENTERS HERE
DIRECTION OF FLOW OF PULP
CONCENTRATE DISCHARGE TUBE

FIG. 2—CONCENTRATE POCKET ISBELL CONCENTRATOR

A number of advantages are claimed for this new concentrator. It has a large capacity, ranging from 50 to 100 tons per 24 hours, due to the method of handling the ore in a deep bed, and the separation of mineral from gangue by jigging action without the use of a transverse current of wash water. Preliminary sizing is unnecessary, and the usual devices for this work can be omitted from the mill system. Fine or slime mineral is readily recovered as long as it is treated with the coarse. The machine requires about the same power as do ordinary concentrating tables. The quantity of water required for regulating the action of the concentrate pockets varies from 7 to 15 gal. per min., under a head of about 15 ft.

## The Application of Cold, Cleaned Producer Gas to High-Temperature Regenerative Furnaces

Under this title Mr. H. F. Smith, general manager of the Smith Gas Power Company of Lexington, Ohio, has published an interesting bulletin on this company's system of generating and distributing producer gas.

In order to characterize first some general features of this system, it may be said that the Smith producer is a mechanically operated suction producer. The shell, lining, and other heavy parts are stationary, and the agitation of the fuel bed is attained by the movement of the grate bars. A centrally located gas outlet is provided which prevents channeling along the producer lining. In conjunction with this is a magazine feed. The grate area is ample so that the rate of gasification is moderate and the production of high temperatures is avoided. The grate surface is large and concentration of the blast at this point is avoided. The ash-pit space beneath the grate is segregated, permitting the distribution of the blast to various parts of the fuel bed to be accurately controlled. The stoking mechanism is also segregated so that the stoking action can be accelerated over any portion of the fuel bed.

Smith producers are provided with the saturator system of vapor control about which more will be said below. The gas output is automatically controlled as to volume and quality and the manipulation of the producer is entirely independent of any conditions that may be imposed at the furnace by the furnace man.

Smith gas is cleaned and cooled before being delivered to the gas mains. The volume of gas to be handled is only about one-fourth that issuing from hot gas producers from the same volume of fuel. The gas may, therefore, be distributed through small unprotected steel pipes. There are no deposits in the mains. While the gas is cooled and cleaned, this is claimed not to involve any loss in thermal efficiency from the precipitation and removal of tar, since provision is made whereby the waste heat contained in the discharge gases from the producer is utilized in converting the tar into fixed gas. With the Smith system both ammonium sulphate and tar can be recovered in marketable form if desired.

Finally a high efficiency is claimed for the Smith producer. "While there is apparently a loss of heat units resulting from the cooling of the gas, this loss is for practical purposes more apparent than real and in regenerative furnaces Smith gas will produce a greater heating effect per pound of coal than can be produced from the same quantity of fuel when gasified in the so-called hot gas producer." This statement will probably meet with opposition, and it will, therefore, be interesting to analyze later Mr. Smith's argument in favor of this claim. But we may first discuss the technical principles by which uniformity of gas quality is obtained in the Smith gas producer. It is based on three principles, (*a*), (*b*) and (*c*).

(*a*) Maintenance of uniform ratios between air and water vapor in the blast to the producer. This is obtained by the use of the "saturation system" in which the air supply to the ash-pit is preheated and saturated with water vapor by being brought into contact with large surfaces of hot water. "With the Smith saturation system not only can the presence of an excess of vapor in the blast be entirely prevented, but any excessive amount of moisture in the gas, from any cause whatever, either through firing of wet fuel, through the liberation of contained moisture from the coal, or from the passage of undecomposed steam through the fuel bed, will be removed by the subsequent cooling of the gas which causes a condensation of any excess of water vapor from whatever source. Accordingly, with the Smith system, the delivery of excessive amounts of vapor to the furnace with the gas is absolutely prevented."

(*b*) Maintenance of uniform rates of distillation of hydrocarbons from the coal. To obtain this in the Smith producer, the fuel supply is uniform from large fuel magazines above the active fire zone into which coal can be discharged as required without producing any disturbance of the gas-making conditions whatever. The fuel descends into the gas-making zone only so fast as the coal below is consumed and in this way sudden fluctuations in the hydrocarbon content of the gas is avoided.

(*c*) Maintenance of uniform temperatures and ample time of contact between the fixed carbon and the blast in the body of the producer. This is obtained by the large grate surface provided and a moderate rate of driving the producer.

The chief novelty of the whole system is to be found, however, in the use of a cold, cleaned gas in the Smith system as against the usual hot producer practice. Naturally Mr. Smith pays considerable attention to this point in his pamphlet. For the purposes of this review it may be considered from three different viewpoints: efficiency of generation of the gas, of its distribution, and of its utilization at high-temperature regenerative furnaces.

### EFFICIENCY OF GAS PRODUCTION

With respect to the *generation of the gas* in the Smith producer the energy balance sheet would show (1) a useful consumption of energy. "The efficient production of gas by the producer process is dependent upon the carrying out of a number of *heat-absorbing* reactions within the fuel bed." The gas in leaving the producer carries with it chemical energy which becomes available in form of heat when the gas is burned with air. (2) Losses in form of unburned carbon in the ash, in form of heat loss by radiation from the producer walls, and in form of sensible heat carried out of the producer by the gas.

Losses in unburned carbon are reduced to a minimum by providing a large grate surface and by a slow rate of driving the producer.

This slow rate of driving also makes it possible "to carry out completely the chemical reactions involved in gas making without carrying the temperature of the fuel bed above very moderate figures." Further the central gas outlet tends to divert the blast from the producer lining so that excessively high temperatures in the latter are avoided and the radiation loss from the producer walls is reduced.

"The most important source of heat loss from the producer is the heat carried over by the discharge of the gases at high temperatures. At this point is wasted not only that unavoidable portion of heat which represents the temperature at which the fuel bed must be maintained for proper working, but also the additional heat losses which results from imperfect and incomplete chemical actions of all sorts within the producer itself. . . . The most direct index, therefore, of the efficiency with which the various chemical reactions in the producer are carried out is the temperature of the gas discharged from the machine. If these reactions are complete a maximum amount of heat will have been absorbed and its energy converted into latent chemical energy in the gas. On the other hand, if the reactions are incomplete, this fact will be indicated invariably by waste of heat which results in higher gas temperature."

At the Alton plant using a Smith producer the average temperature of the discharged gases is between 750 and 800 deg. F. At the Smith Gas Power Company's factory the average temperature of the discharge gases at the point of leaving the producer shell is from 350 to 555 deg. F. Both temperatures are much lower than in usual hot gas producer practice. If an average value for the latter is taken as 1600 deg. F. and the temperature of the exit gases in the Smith producer as 700 deg. F., Mr. Smith figures that this temperature difference of 900 degrees represents a loss of 1620 B.t.u. per pound of coal—quite an appreciable loss.

The whole argument of Mr. Smith is decidedly interesting. It would be very illuminating to get for comparison an exact numerical energy balance sheet for the Smith producer and for a hot gas producer, with detailed analyses, temperature records, etc. There is surely no flaw in the argument that *if everything else is the same*, except the temperature of the gases leaving the producer, the producer with the lower gas temperature is the more efficient one.

But a few questions would seem to suggest further investigation. If we keep the temperature in the producer purposely down, how do we change thereby in detail the chemical reactions? The final net result seems very satisfactory, as indicated by the composition of Smith producer gas, given as the average of five analyses made at different times at different plants, using different grades of bituminous coal: 5.2 per cent $CO_2$, 0.9 $O_2$, 25.0 CO, 4.3 $CH_4$, 14.6 $H_2$, 50.0 $N_2$; per cent combustibles, 49.9; average heating value, 172 B.t.u. per cubic foot.

Another question is this: Is not the efficiency of the gas producer, taken for itself, only a matter of purely theoretical interest? Is not the important matter from a practical standpoint a high efficiency of gas production and utilization combined? For the sake of utilization in the regenerative furnace, is it not better to have hot gas? This is certainly a pertinent practical question. Mr. Smith's answer to it will be found below under the heading: Utilization of Gas in Furnace.

### DISTRIBUTION OF GAS

That for distribution purposes cold gas has decided advantages, is evident. The volume is so much smaller and the distributing flues may be made correspondingly small. The gas having been cleaned is free from impurities which would block up the flue and would require to be periodically removed.

But Mr. Smith points out another advantage of purely chemical nature which is liable to be overlooked. "Cold producer gas remains unaltered in composition and is delivered to the furnace in exactly the same physical and chemical state as when generated at the producer. This is by no means true of hot gas," on account of the liability of carbon monoxide decomposing into carbon dioxide and free carbon (forming soot), or of the reaction between methane and water vapor, resulting in the production of carbon dioxide and the liberation of hydrogen. Such reactions reduce the heating value of the gas per cubic foot.

### UTILIZATION OF GAS IN FURNACE

"It has been commonly assumed that the thermal energy delivered to a regenerative furnace by the heat carried in hot producer gas contributes directly to the furnace efficiency. Recent careful investigations along this line have indicated that this is by no means universally true. It has been shown both from theoretical considerations and by practical tests that the direct and immediate effect of delivering hot producer gas to the checkers of the regenerative furnace is *to raise the temperature of the stack gases* of the furnace. . . .

"The amount of heat present in the producer gas as sensible heat must certainly be wasted at one point or another. Either it may be removed from the gas at the producer and taken up again in the regenerators at the furnace, with a corresponding lowering of stack temperature, or it may be carried into the regenerators with the producer gas with a corresponding increase of the stack temperature. In either case nothing whatever is contributed to the temperature of the hearth in this way.

"It has been pointed out that by cooling the producer gas, tar and other combustible constituents are precipitated from the gas and lost. This is not by any means the case in the Smith system, since this tar is completely fixed and gasified in the producer, the waste heat contained in the outgoing gases being utilized for this purpose. There being no direct loss in plant efficiency from cooling the producer gas, it remains to be shown that there may be gains in furnace efficiency incident to this process. These gains undoubtedly do exist." First, there is the precipitation of any entrained moisture which would represent a loss and a disturbing element in the furnace operation. Further the process insures more uniform gas quality.

In addition, "with cold gas distribution the supply of gas to the furnace is absolutely and directly under the control of the furnace operator. Small valves of ordinary construction will positively regulate the flow of gas and this will be independent of conditions of stack draft at the furnace or any condition imposed by the requirements of producer operation.

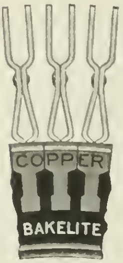
"The aggregate gain to be anticipated from all of the advantages will depend to some extent, of course, on the expertness with which the two types of apparatus are manipulated."

## Bakelite for Commutator Insulation

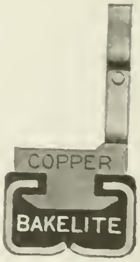
To find out the actual as well as the relative strength of auto starter and lighter commutators, the U. S. Light & Heating Company, of Niagara Falls, recently carried on several tests. The last commutator tested gave by far the best results. This commutator with bakelite molded insulation, proved practically indestructible; it was speeded up to 9060 r.p.m., or 24,600 ft., per minute peripheral speed before going to pieces. As the maximum speed at which such a commutator would be operated in service is only 3500 r.p.m., the factor of safety in the above instance would be 6.7, since the force tending to break the commutator varies as the square of the speed.

COMPLETED COMMUTATOR

It is interesting to compare this test with the previous tests made by this company on commutators made up of brass and steel rings with mica between rings and bars. These constructions proved inferior to the bakelite commutators for the brass commutators went to pieces at 6000 revolutions, while the steel commutators would stand only approximately 8000 revolutions.



CROSS-SECTIONAL VIEW



LONGITUDINAL SECTION, SHOWING INSULATION

Since this test was made there has been a slight change made in the design so that the U. S. Light &

Heating Company are of the opinion that their bakelite commutators will stand 10,000 r.p.m.

The type of commutator tested is shown in the accompanying illustrations, the sections showing the construction of copper segments, steel rings, and bakelite insulation. The commutator complete weighs 8.46 lb., and has an outside diameter over the tangs of $13\frac{3}{8}$ in. When tested, the tangs were removed so that the commutator then weighed 7.06 lb. and had an outside diameter of $10\frac{3}{8}$ in. This is the diameter at the commutator face.

In order that the commutator, while being tested, would approach service conditions as to temperature, it was heated up to 265 deg. Fahr. before testing; this temperature being higher than would occur in service. Calculations show that the disrupting forces, that is, the force tending to pull the commutator apart, was 15,230 lb. per sq. in. As this was resisted by the tensile strength of the steel rings and bakelite molded insulation, the holding power of the bakelite and steel rings is evidently equal to this figure.

In addition to having the high tensile strength for commutator insulation, bakelite possesses other qualifications; it has high dielectric strength, will not soften under heat up to at least 400 deg. Fahr. and is impervious to oil and moisture.

---

## A Fume and Smoke Recorder, Monitor, and Precipitator, and an Instantaneous Thermostat

BY W. W. STRONG.

During recent years great advances have been made in our knowledge of the electrical properties of gases with the result that a number of new electrical instruments have been developed in connection with furnace operations. An illustration is the electrical precipitator* for removing fumes and smoke from gases. A new type of apparatus is the fume, dust and smoke recorder and monitor.

### The Recorder

The fume, dust and smoke recorder is an apparatus designed to register the amount of fumes, dust or smoke in gases. At the same time it may be made to automatically regulate other kinds of apparatus. The mode of making records may include the plotting of a curve on a paper drum or integrating the total time that fumes or smoke of a given density have been emitted.

In the case of smoke many city ordinances permit a few minutes (say six) of smoke emission per hour. The integrating recorder gives the total time in a given interval that the stack has emitted smoke exceeding a certain density. The stack may smoke 3 minutes now, 7 minutes later, 8 minutes later, etc., and the recorder is adjusted so that a watch or clock runs during the smoking periods. In the above example it runs $3 + 7 + 8 \quad 18$ minutes.

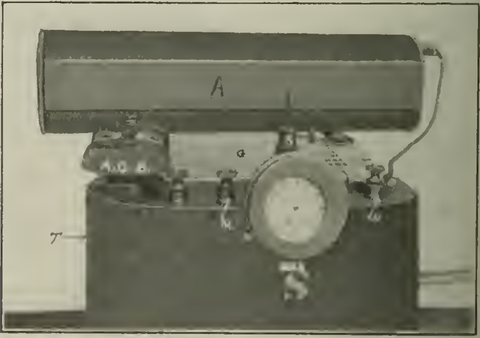
The watch or clock face can be placed so as to be seen by the furnace operator so that he knows what the character of the fume or smoke emission of the furnace stack is at any time. The recorder may be of a portable or stationary type.

The operation of the fume and smoke recorder is very simple. An electrical discharage is given the opportunity of either flowing between electrodes forming an air-gap in the fume or smoke stack or flowing into a condenser and charging it. In the figure a portable recorder is shown. The main part of the apparatus is a step-up transformer T of small current-consuming capacity. The terminals of the transformer are connected in parallel to the stack gap and a condenser in the upper part of the apparatus. By proper setting the condenser is charged whenever the fumes or smoke in the stack exceeds a certain predetermined density depeneding on the length of the gaps. When the condenser is charged the watch or clock is started. In the figure the watch is shown. The only adjustment to be made is that on a spring S holding one of the condenser plates.

It is thus seen that the fume and smoke recorder is very simple in operation, contains no moving parts except the watch and the lever which starts and stops the watch. M and N are binding posts which can be connected to any 110-volt 60-cycle lamp socket. The energy consumed is about 80 or 100 watts. No chemicals are used. The apparatus can be placed in any convenient place and requires practically no attention.

### The Monitor

The fume and smoke monitor is essentially the same in its action as the recorder with the difference that in this case an electric circuit is opened or closed instead of a watch being started or stopped. In this way bells, lighted signs and other indicating apparatus may be operated. The value of the monitor lies in part in the fact that its action is instantaneous so that the furnace operator can immediately remedy conditions. In the case of a coal furnace the firemen can immediately change the conditions so that smoking shall cease.



FUME, DUST AND SMOKE RECORDER

In the figures A C B is a bell which attracts attention to the illuminated sign A. This sign is behind a crown glass screen and contains the lettering "Fuming" or "Smoking" and any suitable directions. The figure represents a combined portable monitor and recorder.

In the case of the monitor the only part requiring any attention is that of the contact points held by the spring S. As the contact points wear away the spring should be slightly lowered. By using tungsten or similar metal the wearing away of the contact points is small.

### The Precipitator

The writer has developed a method* of precipitating any kind of fumes, dust or smoke by the use of an electrical corona discharge. This method is probably the most efficient way of precipitating fumes, dust and smoke under many commercial conditions. In the above figure the apparatus can be used so as to precipitate the fumes, dust or smoke if the quantity of

---

*See Proc. A. I. E. E., June 27, 1913, *Journ.* Franklin Inst., Sept., 1912.

**Journ.* Franklin Inst., Sept., 1912. Proc. Am. Inst. Elec Eng., June 27, 1913.

gas is small. An instrument of this type will handle in the neighborhood of 80 or 100 cu. ft. of gas per minute. An instrument of this kind is very convenient for precipitating any kind of fumes or smoke in small quantities. Very fine smoke such as cigarette smoke is precipitated beautifully.

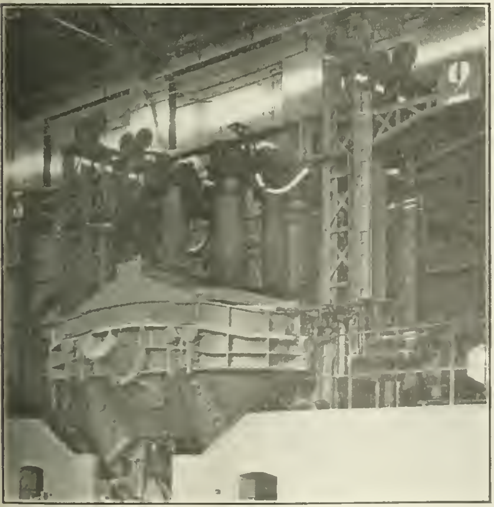
### An Instantaneous Thermostat

In the case of ordinary thermometers, thermopiles, pyrometers, etc., there is a certain degree of sluggishness. This sluggishness is greatly increased by the fact that the active thermal detecting parts are usually enclosed in a protecting case which is more or less heat-resisting. In the case of my recorder and monitor there is no case of any kind about the "stack" electrodes so that the recorder or monitor indicates almost instantaneously when the conditions in the gap change.

Under certain conditions as, for example, the intermittent existence of flame or hot gases in the gap, the monitor apparatus can be adjusted to act as a practically "instantaneous" thermostat. The sensitiveness and quickness of action of purely electrical circuits is well known and as the flame or hot gas is the region through which the electrical discharge itself takes place it is easily seen how nearly instantaneous its action can be.

## Electric Steel for the French Army and Navy

The Cie. des Forges & Acières Electriques, M. Paul Girod, at Ugine, Savoie, France, is reported to be working busily day and night its large electric furnace plant for the production of special steels for the French army and navy. The accompanying illustration shows the latest addition to the steel-making equipment of this plant. It is a Girod furnace capable of melting up to 25 tons of cold charges of scrap iron and steel.



TWENTY-FIVE-TON GIROD ELECTRIC STEEL FURNACE

The plant has been remodeled and now contains two Girod electric furnaces of $2\frac{1}{2}$ tons capacity each; two Girod furnaces of 10 to 12 tons capacity each, and one furnace, as shown above, with a capacity up to 25 tons of cold charge.

A separate plant in the same town produces large quantities of ferro alloys by means of the electric furnace process.

## Suspension Type Storage Bins

The design of storage bins for ore and similar material is an item in mill and smelter construction that requires more careful consideration than it sometimes receives. Efficiency and economy in operation require that such bins should discharge their contents readily without resort to shoveling or mechanical means for emptying them; and the design should take into consideration the angle of repose unit weight and size of the material to be handled. The first cost of the structure should be as low as possible but should not be sacrificed to low cost of maintenance; neither should the structure be subject to heavy depreciation.

A storage bin embodying these ideal features is the Baker suspension type manufactured by Arthur G. McKee, of Cleveland, O. As shown in Fig. 1 the bin combines the principles of the suspension and hopper types, the suspension principle being utilized in the support of the structure and the hopper in the design of the bin bottom. This combination makes possible a slope of sides and bottom greater than the angle of repose of the contents, thus insuring free flow and complete discharge.

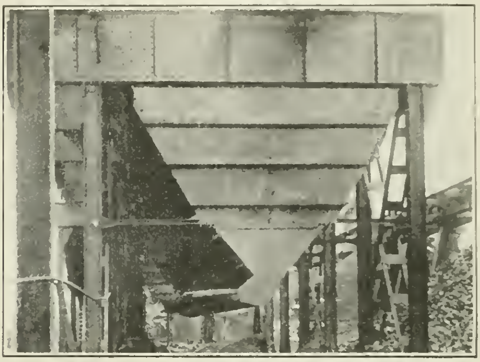


FIG. 1—SUSPENSION TYPE STORAGE BINS

A variety of materials can be used in the construction of these bins—wood, concrete or steel, or a combination. The suspension rods and bottoms are built in interchangeable units, thus facilitating erection. One type of bin lining, suitable for coal and ash, is concrete laid on asbestosteel, which is sheet metal with a protective coating of asphaltum covered with asbestos. In another type, concrete slabs $2\frac{1}{2}$ to 4 in. thick form the lining. Wooden lining also may be used for suitable purposes.

For the storage of ore and similar abrasive materials, the bottoms are of steel throughout, made in unit lengths equal to the spaces between supporting bents. The discharge outlet is continuous for the entire length of the bin, and the discharge of material is governed by a continuous series of quadrant gates that may be operated mechanically or by hand. The space beneath the bins is unobstructed, and is available for handling the discharged material. The entire design is flexible, and the bin may be enlarged by adding new units.

**The Bristol Company**, of Waterbury, Conn., celebrates this year the twenty-fifth anniversary of its foundation. Its plant has grown at the rate of doubling the floor space once every five years. The growth of the business has been especially large during the last six years, since in 1908 the president of the company, Mr. Wm. H. Bristol, again took up the general management.

## An Adiabatic Calorimeter

The calorimeters in general use are subject to many errors, namely those of radiation through the surrounding wall, of conduction through the metallic parts and the thermometer, and those due to the inaccuracy of the thermometer readings.

The following description of the Riche adiabatic calorimeter deals with an attempt to eliminate all these errors, through the use of a *vacuum cup* with a suitable covering, proper precaution having been taken to insulate the different parts.

*Description of Apparatus.*—In all calorimetric work the rise in temperature, multiplied by the quantity of water affected, gives the calories directly, provided there is no loss or gain in heat. Fig. 1 is a sectional sketch of the bomb and calorimeter, which has been designed. It consists of a bomb, *a*, which may be of any type; of a vacuum cup, *b*, containing water; a stirrer, *j*, and a thermometer, *T*. The stirrer is of the screw propeller type, which is very efficient. The vacuum cup is of standard size, 14 cm. wide, 30 cm. high, inside measurements, and was obtained through the Vereinigte Fabriken f. Laboratoriumsbedarf, Berlin, Germany.

The bomb is of the Mahler-Kroeker porcelain type and should last for 8000 combustions; and, inasmuch as it has two outlets, 4-5 determination of carbon may be made. The support for the bomb is a hinged ring, *c*, supported by two brass rods connected with the cover. The rods are insulated by passing them through hard rubber, *m*, and a hard rubber cap is screwed on the end of each rod.

To prevent any possible heat loss from the vacuum cup, it is surrounded by an oak box, *w*, lined with 1-in. pressed cork, *o*, glued to the wood. On the cover, in addition to the cork, is glued a piece of hair felt, *f*, ½ in. in thickness, effecting a tight joint with the top of the vacuum cup.

A hinged door in the front facilitates the handling of the vacuum cup and the cover is raised and lowered by means of telescope tubes, thus giving opportunity to place the bomb in the split ring and to adjust the ignition wires. After the cover is lowered the thermometer is placed in position through a hole in the cover, into which is screwed a brass tube to support and protect it.

*Method of Making a Combustion.*—The substance to be burned is prepared, weighed and placed in the bomb, which, after being charged with 30 to 40 atmospheres of oxygen, is then placed in the split ring and the wires connected. The water in the vacuum cup is brought to any temperature within plus or minus 5.0° of the room temperature, the cup is then placed in position, the door closed and the top lowered. The thermometer is adjusted and the motor started. Readings are then taken until the temperature of the water becomes constant. The heat absorption is complete when the thermometer shows a constant temperature for three successive minutes.

Temperature equilibrium having been established, the bomb is removed, opened and rinsed with water, and the rinsings are titrated with one-tenth normal alkali for nitric acid, using litmus as an indicator.

*Method of Ignition.*—Ignition of the substance in the bomb is accomplished by a current from three two-volt storage cells, which first passes through a 3-ampere fuse wire, in series with a platinum wire within the bomb itself. The platinum wire is connected with the substance to be burned by means of a linen thread of sufficient size to secure ignition. The fuse assures the constancy of the heat ignition.

*The Need of Exact Determinations.*—Whereas other types of the calorimeter require frequently repeated readings and a consequently complicated system of calculations because of imperfect insulation, the Riche calorimeter needs only minute readings. It requires from three to five minutes for the temperature of the water to become neutral and stationary. The operator may ignite his material and then do anything that he pleases during the short interval that follows the final reading.

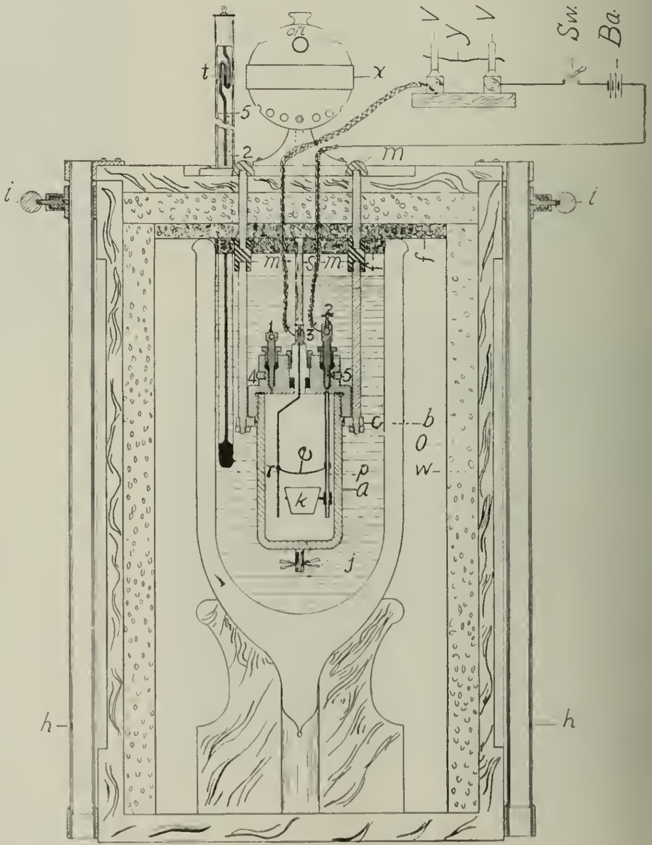


FIG. 1—ADIABATIC CALORIMETER

*Calculation of Results.*—The reading at ignition is taken as the initial reading. This subtracted from the final reading gives the total rise. This rise multiplied by the weight of water (plus the hydrothermal equivalent of the apparatus) gives the total number of calories liberated. From this is taken the heat resulting from the ignition, and the nitric acid formed. This result, divided by the weight of substance, gives the calories for the unit of material oxidized.

The Riche calorimeter, therefore, saves from 50 to 75 per cent. of the operator's time. To this saving of time there is added the perfection of the entire calorimeter device. The calorimeter as an established laboratory device will soon be employed generally in connection with the large consumption of all fuels, foods and commercial products, the value of which depends upon their heat contents.

---

## The Metal Spray Process

The Schoop spray process for the production of metallic coatings is well known to our readers from two articles of the inventor, Mr. M. U. Schoop in Zurich, Switzerland, published in our Vol. VIII, p. 404, (1910) and Vol. XI, p. 89, (1913).

The process has naturally been the subject of much speculation and inquiry since it appeared in Europe. Its recent improvements, now protected in the United States, and the acquiring of rights for this country by the Metals Coating Company of America, People's Gas Building, Chicago, make it possible for us to publish some further details of its commercial applications.

The corporation now owning all the United States rights of Schoop and other European inventors already possessed the basic patent, which controls impacting of metal irrespective of the nature of the apparatus used, and the company is therefore in a position to utilize in metal spraying a group of inventions no one of which would have sufficed for the present stage of commercial development which the process has attained. Mr. John Calder is the president of the Metals Coating Company of America.

As described in detail in Mr. Schoop's former articles, the principal apparatus used in the spray process is a "pistol." Into one side of it a cold metal wire on a reel is pulled in continuously at a uniform rate. Within the pistol the metal wire is melted by a hydrogen-oxygen flame and by means of a violent air-blast the melted metal is "fired" out of the pistol in form of a very fine spray at a very high velocity.

If the nozzle from which the metal spray issues is pointed from a distance of 5 in. at the surface of various objects of metal, wood, paper, stone, clay, cement, cloth, silk, glass and other substances, the surface receiving the spray becomes coated with a dense adherent film of the metal composing the wire fed into the pistol. Elemental and alloyed metals may be handled with equal facility. Lead, tin, zinc, aluminium, copper, brass, bronze, German silver, etc., may be fed into the instrument at will and deposited freely in coatings from 0.001 in. upward in thickness.

The temperature of the molten metal spray at the nozzle may be varied according to the wire used from 700 deg. F. to 2000 deg. F., yet 5 in. away none of the objects coated is injured or altered in the act of metallizing them. Matches held in the zinc spray are immediately coated over without ignition, and the thinnest paper and wood receive the impacting particles into their pores without charring. Brass issuing at 1550 deg. F. from the nozzle is deposited on the thinnest silk fabrics without damaging the textile.

In considering what occurs in the Schoop process it is necessary to bear in mind a singular fact: the sprayed metal moves only 6 in. between its points of fusion and the object to be coated, yet it does *not* reach the object in a molten state. It even possesses so low a temperature that it can be safely directed upon the hand for a moment without injury and can be continuously impacted upon materials such as cloth, paper, wood and even celluloid, which would be immediately consumed by the heat of any molten metal. A box of matches can be coated all over to form a seamless metal case without a single match being ignited.

The reason is that the gaseous medium used is much larger in volume at any moment than the drop it has pulverized and is carrying and the gas is expanding so rapidly that its temperature is far lower than that of the spray. A rapid exchange of heat therefore takes place between them which consolidates the molten particles and gives them a temperature far below the melting point. If the particles arrived in a liquid state at the base with the observed velocity of 3000 ft. a second they would simply splash on the plate and largely rebound. As a matter of fact they impact and interpenetrate freely and the later bombarding particles unite with the earlier ones to form homogeneous compact bodies. In accounting for the observed action of the Schoop spray at the receiving base, it is supposed that the cooled particles of metal just before impinging with great velocity on a hard surface are in an abnormal physical condition. Due to the heat of collision they pass directly into a vapor which condenses and solidifies on the relatively cold receiving body, penetrating by osmotic pressure the superficial pores of the base where any affinity for the latter exists and, otherwise, driven in by the pressure behind it.

In either case it condenses and solidifies after penetration and is effectively dovetailed into the base. The hammering and bombardment of the solidified first coat by the minute succeeding particles is practically a process of cold working. The entrained particles liquefy and solidify so rapidly that the metal has not time to return to its natural crystalline state.

The theory just outlined seems to be supported by examinations of the sprayed deposits, for the structure of the metal coatings and of the whole bodies produced by the Schoop process is always found to be amorphous and vitreous throughout.

This characteristic is of great importance to many large metal industries.

The spray nozzle is provided with three hose pipes which lead oxygen, hydrogen, and air from their respective containers to the burner tube and blast nozzle which are concentric. The cost of operating the Schoop process in the United States has been carefully ascertained through experience with the appliance during the last six months. The seven metals most commonly used for protecting or decorating surfaces are lead, zinc, aluminium, brass, German silver, bronze and copper. When the gases are purchased in small quantities in the usual containers, the cost of spraying lead including the cost of wire, compressed air and labor, is between 1 and 2 cents a square foot and 1 lb. of lead can be sprayed in less than a minute. The other metal coatings vary with the initial price of raw material and its relative hardness.

Where concerns operate a number of pistols they usually generate their own gases or purchase them on a wholesale basis thereby effecting considerable saving in the cost of operating the process.

The spray process may be applied in two entirely different ways—namely, the coating produced may be made detachable or adherent. Accordingly the applications are different.

By means of the detachable sprayed coatings it is possible to copy in metal any metallic, cement or composition object.

On the other hand, permanent coatings are used either for decorative purposes or to preserve surfaces from decay in the atmosphere or from moisture or any form of chemical attack.

Every kind of hardware of iron, steel or alloy at present enameled or dipped or coated with glazes can be plated cheaply with aluminium, tin, or any desired metal. Cooking vessels can be so lined and give better wear than all-aluminium products, at much less cost; steel tanks can be perfectly protected by a lead coating, and vessels liable to rust or to the action of chemicals can be lined cheaply with any desired protection and repaired as quickly.

Every kind of domestic hardware, whether of iron, steel, and any other simple metal, or of alloys, can be coated with a layer of any selected metal, and glass enamel and glazes can also be rapidly applied as lining by the same implements and process. Stoves and utensils of all kinds can be rapidly decorated and protected by sprayed nickel or any other metal desired.

Cooking vessels, both domestic and for manufacture of foodstuffs, can be lined with any metal, and repairing of linings is a rapid, simple process and very inexpensive.

Beer kegs, for instance, requiring frequent and expensive treatment with pitch, can be readily coated inside with aluminium, giving a clean and durable protection, and wines and liquids now subject to leakage and loss in casks can be completely protected by suitable lining in the containers. Brass cloth for chemical plants can be lead sprayed for protection; cast iron pots for alcohol, acid and other stills can be lead lined and all forms of pipes, tanks, reservoirs and containers for acids, oils or chemicals can be protected quickly with any required metal.

Calico printers' rolls can be coated rapidly with homogeneous and adherent copper.

Iron and steel structural work can be provided with a permanent rust-resisting metal coating.

Much of the metal welding can be carried out by the spray process which neither heats nor distorts the object under treatment and is relatively inexpensive.

## Vitreosil

"Vitreosil Apparatus for Chemical Laboratories" is the title of an interesting neatly illustrated pamphlet just issued by the Thermal Syndicate, Ltd., of New York. It contains notes on the various laboratory ware made from vitreosil (fused silica), such as combustion tubes, pyrometer tubes, test tubes, triangles, plates, rods, casseroles, dishes, crucibles, flasks, muffles, trays, etc. An interesting bibliography is added.

In the introduction the general physical and chemical properties of vitreosil are discussed. Vitreosil is 99.8 per cent pure $SiO_2$. Its coefficient of expansion is 0.00000059, that is, it is so small that vitreosil may be subjected to rapid changes of temperature without danger of breakage. It should not be exposed, however, *continuously* to temperatures over 1200 deg. C.

Vitreosil is absolutely insoluble in water. It is unaffected by mineral or organic acids with the exception of hydrofluoric, and at high temperatures, phosphoric acid. The action of phosphoric acid only commences at 400 deg. C., so that for all ordinary work with this acid it can be safely used. Aqua regia or a mixture of chromic and sulphuric acid do not attack vitreosil at any temperature.

Vitreosil resists high temperatures without injury and its insulating value decreases much more slowly with increasing temperatures than is the case with glass or porcelain. These unique properties permit the successful employment of vitreosil as a high-temperature insulator where other ceramic materials are unsatisfactory. It offers the further advantage that moisture does not readily condense on its surface. The translucency of the glazed quality is a valuable property when the material is used in the construction of electrical heating apparatus.

## Niagara Falls Meeting of American Electrochemical Society

The twenty-sixth general meeting of the American Electrochemical Society will be held in Niagara Falls from Thursday to Saturday, October 1 to 3, 1914. Headquarters will be at the Clifton Hotel.

The Board of Directors will meet on Wednesday evening, September 30.

Sessions for reading and discussion of papers on Thursday morning, October 1, and Friday afternoon, October 2 at the Clifton Hotel.

Symposium at the FitzGerald Laboratories, Highland and Vermont Avenues, Niagara Falls, N. Y., Saturday, October 3, morning and afternoon.

*Excursions and Entertainments:*

*Thursday afternoon, October* 1. Excursion to Foster's Flats, Niagara Gorge, a spot not much visited by or well known to tourists. A local authority on the flora, fauna and history of the spot will be present and give information of interest. Light refreshments. This event will be interchangeable with the Professional Session scheduled for Friday afternoon in the event of unfavorable weather on Thursday.

*Thursday evening.* Smoker, "The Home of Section Q." The section has placed a strict censorship on all communications from Niagara Falls relating to the program.

*Friday morning, October* 2. Visits to plants and power houses. A number of interesting plant visits are being arranged and a full list will be announced later. Besides the power houses, the International Acheson Graphite Company and the Niagara Alkali Company, under some restrictions, will be visited. A much larger number of plants will be open to visitors than ever before, this being one of the unusual attractions of the meeting.

*Friday Evening.* Subscription dinner. No speeches. Experimental lecture following.

*Saturday Evening, October* 3. Kommers at Niagara Club or Fort Schlosser Club.

A feature of the meeting will be an Experimental Symposium on "The Practical Side of Electrochemical Investigation," occupying two sessions on Saturday, and consisting of a number of demonstrations of methods and apparatus. Promises of participation have already been secured from Mr. F. A. J. FitzGerald, Research Laboratory General Electric Company, Research Laboratory Westinghouse Electric and Manufacturing Company, Mr. L. E. Saunders, Mr. A. T. Hinckley, Mr. Max Mauran, Dr. Carl Hering and Mr. Lynn Bradley, and others.

The symposium will be held in the FitzGerald Laboratories, where the excellent facilities available will permit a display of extreme interest and of very diversified character.

*Ladies Arrangements:*

All sessions will be open to ladies. On Thursday evening an entertainment will be provided, while members are attending the smoker. The Foster's Flats excursion will be especially interesting to ladies and they are urged to make the trip.

The complete program of papers will be published in our next issue.

---

**The Johnson Electric Smelting, Inc.**, plant will be located probably at Hamilton, Ill., opposite Keokuk on the banks of the Mississippi River. It has been found impossible to procure a suitable site on the Iowa side of the river. The Illinois side is much better from standpoint of favorable freight rates on spelter, copper matte or base lead bullion to New York, Pittsburgh and Chicago. Freight on ores is same from West on either side.

## Personal

Mr. **F. T. Boyer**, formerly connected with the National Lead Company at their Collier works in St. Louis, Mo., is now superintendent of the Philadelphia smelting works of Merchant & Evans Company.

Mr. **J. M. Callow**, of the General Engineering Co., Salt Lake City, has returned west from a trip to New York City.

Dr. **Hector R. Carveth**, works manager of the Niagara Electrochemical Company, tried to get to Europe on the steamship *Kronprinzessin Cecilie* and failed.

Mr. **H. C. Clark**, formerly Ohio agent of the E. F. Houghton Company, is now connected with the Stupakoff Laboratories, pyrometer manufacturers, of Pittsburgh, Pa.

Mr. **George E. Collins** has returned to Denver from London, where he has been on professional business.

Dr. **Stuart Croasdale**, of Denver, is engaged in professional work in British Columbia.

Mr. **F. H. Emerson** has been appointed Boston district manager of the Bristol Company, with headquarters in the Old South Building.

Mr. **C. M. Eye** has been making metallurgical tests at the experimental plant of the Colorado School of Mines, Golden, Col., prior to designing and erecting a cyanide mill for the Benguet Consolidated Company, Bagui, Philippine Islands.

Mr. **Jacob Hasslacher** is convalescing at his summer home in Elka Park, N. Y. On the 8th of August the silver anniversary of the founding of the park was celebrated, of which Mr. Hasslacher is the president. Since Mr. Hasslacher was not well enough to attend the banquet and other festivities, the members and guests of the Park honored their president with an ovation and a long torchlight parade headed by a large brass band. More than two hundred took part, including many engineers and chemists.

Mr. **H. C. Hoover** has accepted the temporary chairmanship of Camp Bird, Ltd., and the Santa Gertrudis Co. Mr. **R. J. Frecheville** has resigned his position as director of the companies and assumes the chairmanship of the technical committee. Messrs. **F. A. Govett** and **F. H. Hamilton** have joined the boards of both companies, and Messrs. **Norman Craig** and **George de Pass** have joined the Santa Gertrudis and Camp Bird boards, respectively.

Mr. **D. C. Jackling** is making one of his periodical trips of inspection to Alaska. From Seattle he will be accompanied by a party of guests on his yacht the *Cyprus*.

Mr. **Lorin Kemp**, until recently in charge of cyanide mills of the North Star Mines Co., Grass Valley, Cal., has resigned to accept a position in Chile.

Mr. **D. J. Lewis, Jr.**, consulting engineer, has just closed a contract with the Cape Cruz Company of New York to furnish for their sugar factory a trap system to collect from their juice heaters, evaporators, vacuum pans and live steam drips, a maximum amount of 100,000 pounds of condensation per hour and return it automatically to the boilers. The pressures will vary on the different devices from zero to 125 pounds. Mr. Lewis was formerly manager of the "Bundy" trap and for three years ending May 1, sales manager and engineer for the Lytton Manufacturing Corporation. He is now associated with Mr. W. J. Wayte, and they are making a specialty of power house, sugar house and chemical works efficiency. Mr. Lewis is sales agent for the Lytton Manufacturing Corporation for New York and New England, and Mr. Wayte is the United States agent for the Watson, Laidlaw & Company, Limited, of Glasgow, Scotland, manufacturers of centrifugal machinery.

Mr. **W. B. Mangan** is manager, and Mr. **W. N. Rossberg** superintendent of the Timber Butte Milling Co., Senator Clark's new zinc concentrator at Butte, Mont.

Mr. **L. M. Marshall** has resigned as assistant general manager of A. J. Haws & Sons, refractory manufacturers, Johnston, Pa. Prior to six months ago Mr. Marshall was chief engineer of the Cambria Steel Company.

Mr. **Kirby Thomas** was in Denver recently on his way to Colorado mining districts on professional business.

Mr. **H. N. Thomson**, formerly with the Anaconda and International smelting companies is at Clarkdale, Ariz., with the United Verde Copper Co.

Mr. **Samuel S. Webber**, of Trenton, N. J., has resigned his position as chief engineer for the Trenton plant of the American Steel & Wire Co.

Mr. **F. S. Youtsey**, of Denver, Col., is at St. Francois, Mo., erecting a mill for the St. Louis Smelting & Refining Co.

## Digest of Electrochemical U. S. Patents

PRIOR TO 1903.

*Arranged according to subject-matter and in chronological order.*

*Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.*

AQUEOUS BATH (ELECTROPLATING) *Continued*

537,403, April 9, 1895, George D. Burton, of Boston, Mass.

Relates to the extraction of oil and grease from wool. Within a suitable tank, holding about thirty gallons of solution, is placed preferably a solution of bichromate of potash, of specific gravity 1.05; or a solution of five pounds chloride of sodium, three ounces of sulfuric acid, and twenty gallons of water may be used. The wool is now immersed, at first a current of sixty-five amperes at two hundred and twenty volts is passed between electrodes of preferably a foot square. When the desired temperature is reached, the current is reduced to about twenty amperes. The preferred temperature is about 155 deg. F. The oil or grease rises to the surface of the liquid and may be removed; after the wool is sufficiently cleaned, it is removed and washed.

554,795, February 18, 1896, Dexter Reynolds, of Evansville, Indiana, Assignor, by direct and mesne assignments, to T. M. Steinmetz, M. A. Tobin, August Holthaus, and George P. Heckel, of St. Louis, Mo.

Relates to an apparatus to be used in laundering, and is designed to thoroughly cleanse and disinfect wearing-apparel and other fabrics of all disease germs without injury to such fabrics. The apparatus consists of two electrodes, for example zinc, placed in the bottom of the tub, and connected by insulated wires to a suitable source of current. The wires pass through V-shaped flexible tubes that are inserted through the handles of the tub. By subjecting apparel or other fabrics, such as bed-clothes, surgical cloths, bandages, sponges, etc., to immersion in a body of water or other laundering liquid charged with and decomposed by electricity, they are not only thoroughly cleansed, but all disease germs of whatever nature are absorbed and destroyed, thus saving such apparel or fabrics from destruction and rendering them capable of further use. The apparatus is also applicable for sterilizing liquids.

558,176, April 14, 1896, Philip Huber, of Saginaw, Mich.

Relates to an apparatus for decomposing water by electrolysis, and consists of a tank in which are placed bottomless jars having outlets at the top, the outlets being connected to suitable gas receivers. In each jar is placed a platinum electrode. The evolved hydrogen and oxygen may be burned in a suitable burner and heat any object desired, the heated object radiating heat to the surrounding space.

558,717, April 21, 1896, Henry L. Brevoort, of Brooklyn, N Y.; Gertrude L. Brevoort, executrix of said Henry L Brevoort, deceased, assignor by direct and mesne assignments, to the Electro Waterproofing & Dye Fixing Company, of New York, N. Y.

Relates to a process for waterproofing various fabrics made of animal or vegetable fibers, such as threads, cords, ropes, string, cotton sheeting, sails for ships, cloth, etc., made of cotton, wool, or silk. The fabric is wet with water, such as city water, preferably neither acid or alkaline, and pressed between two conductors such as plates or rolls, to give a firm contact. The anode is preferably of aluminium or tin, the cathode may be of the same or different metal, or of carbon. In place of aluminium or tin, iron, copper, or silver may be used as the anode, but these may color the fabric; zinc gives fair results; lead, antimony, or bismuth are not desirable as anodes. On passing a direct current through the wet fabric from anode to cathode, with an ameter in circuit, the instrument will at first indicate a sudden rise in current, which will then drop, due presumably to the formation of oxides, and the presence of gases, and then finally rise again; it should be broken when it rises after the preceding drop. If continued after the second rise, the desired object will be defeated and the goods cease to be water-repellent. After the treatment and the fabric is dried, it will be found to be waterproof, or water-repellent, believed to be produced by a metallic oxide formed from the anode, the oxide entering the fabric or its fibers and making them water-repellent. With cotton cloth, voltages from 1 volt to 100 volts have been used, the time of treatment being decreased with the higher voltages. With electrodes of between 2 in. and 3 in. in diameter, using 30 volts and a pressure of about 50 lb. on the electrodes, satisfactory results have been obtained with treatments varying from one second to thirty seconds, preferably about fifteen seconds. In fabrics heavily dressed with soluble matter, the process is not as satisfactory; in fabrics having a dressing or finish containing grease, the water-proofing is difficult because it is difficult to wet the fabric. It is desirable to cover the cathode with a separate piece of cloth when practicing the process.

558,718, April 21, 1896, Henry L. Brevoort, of Brooklyn, N. Y.; Gertrude L. Brevoort, executrix of said Henry L. Brevoort, deceased, assignor, by direct and mesne assignments, to the Electro Waterproofing & Dye Fixing Company, of New York, N. Y.

Relates to the fixing of that class of dyes in which the coloring principle is in solution in the liquid to which the cloth is subjected, and which coloring principle requires a mordant to fix the same in the goods. Such colors may be fixed by subjecting the goods to a direct current after they have been run through the solution containing the coloring principle, the goods being between a metal plate or roller connected as anode, and a carbon or metal plate or roller as cathode. The current is passed through the goods from the anode to the cathode, the water in the fibers is decomposed, and oxygen liberated at the anode, forming an oxide of the metal which enters into chemical combination with the coloring principle contained in the goods, thus fixing the color as though a mordant had been employed in the old way. With different metals, as anodes, different colors may be produced, and different degrees of color can be obtained by varying the concentration of the dye. Each specific material, its thickness, and the dye employed, alter the current conditions, necessary to fix the color. A metal is necessary as the anode, as the oxide of a metal is the fixing agent for the natural color, the oxide being carried into the fiber. The metals best adapted for anodes are aluminium, tin, zinc, lead, copper, iron, and brass. In general, those metals work best whose oxides form with the coloring principle colored salts. An alternating current may be used if metallic electrodes are used on both sides. Engraved plates or rollers may be used as anodes.

## Book Reviews

**Fabrication de l'Acier.** By **H. Noble.** Second edition, revised and enlarged. Large octavo (15½ x 24 cm.), 632 pages, 86 illustrations; price 26.50 francs, in New York $5.30. Paris: H. Dunod & E. Pinat.

The author was a French steel-works superintendent, and his book is a happy combination of theory and practice. It covers only the manufacture of Bessemer and open-hearth steels, omitting entirely crucible and electric-furnace steel. Considering the field covered, we find the chapter on the general properties of steels too brief, but the rest of the book very satisfactory. The author evidently writes directly from his own experience, and is moderate in his theoretical views, yet clear and practical. Large use is made throughout of metallurgical calculations, applied particularly to the thermal phenomena of the steel manufacture. It is unfortunate that the author has, however, neglected the heat of formation of the slags, in each case; some of them are now known nearly enough to be brought into the calculation. This is but a minor criticism on a book full of first-class, first-hand information, of a kind needed by every steel manufacturer, but especially valuable to the makers of Bessemer and open-hearth steel.

**Elektrochemisches Praktikum.** By **Dr. Erich Muller.** 16 x 22 cm., 224 pages, 73 illustrations; price 8 marks. Dresden and Leipzig: Theodor Steinkopff.

The author is director of the electrochemical laboratory of the Dresden Technischen Hochschule, and his work shows throughout his intimate familiarity with the subject. After describing the sources of current, and apparatus used, the first section covers exercises on fundamental laws, comprising tests of Ohm's law, Faraday's law, conductivity of electrolytes, electromotive forces. The next section deals with separation of metals from solution, under different conditions. A long section comprising 27 exercises then follows, on the preparation of important inorganic compounds, such as caustic alkali, perchlorates, etc. The production of organic reactions is covered in 10 exercises. Electrolysis of fused salts is illustrated by the production of aluminium, magnesium and decomposition of lead chloride; electrothermal processes by the production of carbide ferrochromium and ferrosilicon.

The 69 exercises are fairly well chosen, and always clearly set forth. We would suggest substituting the production of carborundum for that of ferrochromium, since it illustrates a different kind of process; and that of sodium for magnesium, as being more instructive, and valuable for its historical associations.

While the plan and method of presentation are excellent, the choice of the exercises could be improved upon in several instances, as above suggested.

# Metallurgical and Chemical Engineering

A Consolidation of Electrochemical and Metallurgical Industry and Iron and Steel Magazine

Vol. XII New York, October, 1914 No. 10

PUBLISHED MONTHLY BY THE
McGraw Publishing Company, Inc.
James H. McGraw, President.
C. E. Whittlesey, Secretary.
John T. De Mott, Treasurer.
239 West 39th Street, New York.
Telephone Call, 4700 Bryant.
Cable Address, Metchem, New York.

Rocky Mountain Office........421 Boston Bldg., Denver, Colo.
Pacific Coast Office......502 Rialto Bldg., San Francisco, Cal.
Chicago Office..........................Old Colony Building
Philadelphia Office.................Real Estate Trust Building
London Office.............Hastings House, Norfolk St., Strand

E. F. Roeber, Ph.D., Editor.
H. C. Parmelee, Western Editor.

J. M. Muir, Manager.

*Yearly subscription price for United States, Mexico and United States dependencies,* $2.00; *for all other countries,* $2.50. (*European exchange,* 10 *shillings,* 10 *marks,* 12.50 *francs.*)

Copyright, 1914, by the McGraw Publishing Company, Inc.

Entered as Second-Class Matter at the Post Office at New York, N. Y., under the Act of Congress, March 3, 1879.

New York, October, 1914. ,

Editorial:
Chemical Manufacturing Possibilities.................. 611
Grinding Ore for Cyanidation.......................... 611
The European War and American Radium Industry...... 612
The War and American Financing Abroad............. 613
Readers' Views and Comments:
The Dependence of Industries on Chemistry. By D. T. Pierce .......................... 614
Railroad Electrification as a Relief of Economic Stresses. By Woolsey McA. Johnson......................... 614
Cost Accounting and the Work of Accountants. By Justin H. Haynes.............................. 614
Nevada State Mine Rescue and First Aid Meet. By Francis Church Lincoln.......................... 615
The Non-Ferrous Metal Market........................ 616
The Western Metallurgical Field........................ 616
The Iron and Steel Market............................. 618
Program of Niagara Falls Meeting of the American Electrochemical Society .............................. 619
The Effect of Steam upon Magnesite Brick or Calcined Magnesite. By R. H. Youngman.............................. 620
The Determination of Phosphorus in Scheelite Concentrate. By E. W. Hagmaier.............................. 620
Grinding Ore for Cyanidation: A Suggested Modification for all Sliming Practice. By W. J. Pentland............... 621
The Possibilities of Hardwood Distillation on the Pacific Coast. By R. C. Palmer.............................. 623
Indeterminate Cases in Mixing Ores for Calculation of Furnace Charges. By Regis Chauvenet................. 626
Refractometry. By G. A. Shook.............................. 630
Cyanide Practice in the Porcupine District, Ont. II. By H. C. Parmelee .............................. 636
Chicago Meeting of American Institute of Metals............ 641
Abstracts of Papers by Lawrence Addicks, George Stone, William A. Cowan, F. O. Clements, S. L. Hoyt, Herbert G. Dorsey, Ernst M. Schmeltz, H. M. St. John, H. W. Gillett and J. M. Lohr, E. B. Guenther, Fred. L. Wolf and Robert B. Burr, H. W Gillett, G. H. Clamer and Carl Hering.
Notes on Chemistry and Metallurgy in Great Britain.... 650
Synopsis of Chemical and Metallurgical Literature..... 653
Recent Chemical and Metallurgical Patents... ........ 657
Temperature Control for Industrial Purposes............ 660
Preparing a Crank Shaft by Autogenous Welding......... 662
Recording Gas Calorimeter.............................. 663
Large Oil Engine...................................... 663
American Manufacturers and the European War........... 663
Personal .............................................. 665
Obituary .............................................. 666
Digest of Electrochemical U. S. Patents (Electroplating). 666
Book Reviews .......................................... 668

## Chemical Manufacturing Possibilities

One of the big problems which this country faces as a result of the European war is the possibility of producing such chemicals as have not yet been successfully produced here on a large scale in competition with Europe, though their production is technically possible in this country in so far as the raw materials are available. The production of dyestuffs is the most notable example. Two lines of thought suggest themselves in connection with this problem.

The first is that the problem is in no way technical. It is purely economic. To the concise yet exhaustive summary of the situation by Dr. Bernhard C. Hesse in our last issue we have nothing to add here but the advice that those interested in the matter should read it again and again. If they did, there would be less foolish talk of lack of spunk in American manufacturers. What is lacking in reality and what is lacking absolutely is a reasonable guarantee that the enormous investment required will not be a total loss as soon as the war is over and the imported dyes and other chemicals can be put on the American market again at the old prices. It seems too much to hope that the consumer—the American textile industry in the case of dyestuffs—would stick to the more expensive home product for reasons of patriotism. Clearly nothing is left but a high tariff and the certainty that the people at large so thoroughly understand the situation as to guarantee the tariff remaining in force for a reasonably long period.

A second line of thought is whether coöperation with European manufacturers in this matter would not be economically preferable to competition. It is a fact that, as a result of the war, American financiers have discovered that industrial chemistry is more than a string of drugstores and are willing to invest heavily in new American chemical industries. It is also reasonable to assume that European manufacturers are beginning to recognize that they would be better off now if they had American factories, even if they had to operate them under a decided handicap. It would be eminently safe and sane for American financiers and European manufacturers to come together.

## Grinding Ore for Cyanidation

When a metallurgical process becomes as firmly established as in the case of cyanidation, we no longer anticipate great or revolutionary changes to take place in its application. In a degree the method becomes standardized due to long and varied experience. Then the largest opportunity for improvement lies in the alteration of some detail to meet special conditions. This, in turn, results in standardizing the practice in certain countries or localities where special economic or metallurgical requirements have to be met. Thus we distinguish broadly between the combination sand-slime method and all-sliming practice. Differences in detail of both methods arise from the introduction of amalgamation or concentration.

We are pleased to present elsewhere in this issue a novel proposal for the modification of all-sliming as generally practiced. The author, Mr. W. J. Pentland, is an operator experienced in the practice of cyanidation in Mexico, where silver ores have been so successfully treated by that process. His suggestion is not offered as being of broad general application, but rather as a detail susceptible of use in special cases. Essentially it involves the introduction of an agitator in the tubemill-classifier circuit, in order to give the separated and reground sand the special treatment it may require, instead of submitting the entire pulp to a treatment demanded by only a refractory, and sometimes small, portion of it.

As we have pointed out above, the suggestion is in line with the trend of metallurgical development—introducing modifications in detail to meet special needs. In view of the different character of so-called sand and slime produced in crushing, it is easily conceivable that, in some instances, the former may be more refractory and require longer time of contact and stronger solution than the latter. In such a case it would appear rational to provide these conditions, in view of the arguments advanced by Mr. Pentland. The proposal will be of interest to cyanide metallurgists, who are cordially invited to offer discussion on the subject.

## The War and American Radium Industry

The bills introduced in both houses of Congress early this year, providing for conservation of radium-bearing mineral land and participation by the government in the business of producing radium, have been reposing quietly in the proverbial pigeon-hole. Considering the tempest which these measures precipitated for a brief time, the long period of calm that has followed might be considered as ominous of their approaching death due to desertion and neglect. The Senate bill is the poorer of the two, but the House bill could easily be modified and made acceptable.

By reason of various tactics employed to delay consideration of the bills, they lost their place on the calendar; but it is quite certain that they will come up again with the government's conservation measures. So much time has elapsed that the principal reason urged by the proponents of this legislation—conservation of radium in the public domain—is now less apparent than formerly, for the prospectors have long since taken their cue from the agitation last spring and located all the outcropping or known deposits of radium-bearing minerals. Land that would now be affected by withdrawal would probably be difficult to prospect, but there is still a chance for the discovery of mineral on such land.

But the advent of the European war has put a different phase on our radium industry, because the old-world markets are now closed to American ore. In fact, there is no market, and even the largest American producer of carnotite and manufacturer of radium has closed its own mines. This has developed a demand from smaller producers for an American market, and quite naturally they now beseech the government to enter the field, buy ores and make radium. It is rather amusing to observe the change in sentiment among owners of radium-bearing land since last spring. Some of the government's most active opponents at that time are now eleventh-hour converts to the conservation policy and are urging the passage of a bill to authorize federal operation of a plant to produce radium, so that a domestic market shall be created. Petitions from the San Juan district of Colorado have been forwarded to Washington, urging governmental action.

The mill of the National Radium Institute at Denver is in successful operation under the direction of the Bureau of Mines. The fact that the plant is to be doubled in size is an indication that the results obtained in the first unit are satisfactory to the backers of the project. Likewise, the success of the government's technical staff in this instance has stimulated the present reaction of mine owners in favor of federal operation of a custom mill.

Incidentally, it is of interest to the American radium industry to note that S. C. Lind and C. F. Whittemore, chemists in the Denver office of the Bureau of Mines, have just completed a research, noted elsewhere in this issue, that establishes the normal ratio of radium to uranium in carnotite, just as in pitchblende. Former determinations indicated a low ratio in carnotite, and as a consequence some European buyers have insisted on making an allowance for the supposed deficiency. The establishment of the normal ratio will have a beneficial effect on the American industry, for carnotite in Colorado and Utah now constitutes the world's largest known source of radium.

## The War and American Financing Abroad

Immediately upon the outbreak of the European war two thoughts arose in the American mind, first that merchandise exports from the United States would be greatly increased, second, that unless prevented by drastic measures there would be an avalanche of offerings in the American market of domestic securities held abroad. To avoid the avalanche of securities the stock exchanges were promptly closed and efforts were made to hinder the exportation of gold whereby the sale in the United States of foreign held securities might be restricted. To provide for the exportation of merchandise it was everywhere urged that an American merchant marine of large proportions should at once be provided, evidently upon the hasty assumption that the establishment of shipping facilities constituted the greatest desideratum in the new conditions suddenly thrust upon the United States.

Time and reflection have shown both these thoughts to be fundamentally unsound. As to the sale of our securities by foreign holders, no forecast could reasonably be made, for the foreign investors are individuals, not nations. The fact that the earning power of American corporations would be vastly less affected than the earning power of many foreign corporations might or might not dispose the foreign investor to sell the American securities first. As to the exportation of American merchandise, it has been already developed very clearly that it is not lack of ocean carrying facilities but inability of foreign buyers to finance purchases and effect payment through the purchase of exchange or the establishment of New York credit that is restricting our merchandise export movement.

The analysis of the real problem presented is simple, and yet there is evidence that it is not generally understood. We must pay as we go in the future, as we have done in the past, yet we have reached the present time without ascertaining with any degree of accuracy how we have paid in the past.

It is only now that an investigation is being conducted, for by the war condition, into the quantity of American securities held abroad, yet the sale of those securities has been one of the important items in what is called the unseen balance of trade. Estimates, or rather guesses, currently made at wide ranges on either side of five billion dollars prove how vague has been our information in the past. While we may soon ascertain the volume of American securities held abroad at the present time, we have missed the opportunity of knowing what the volume has been at various times in the past, and thus we are unable to study intelligently the course of our foreign trade. We have paraded figures of the value set upon merchandise, gold and silver exports and imports for many years, apparently ignoring the fact that precise information on these heads is practically valueless unless we know also the items constituting the invisible balance, freights paid for foreign vessel owners, expenditures of American tourists abroad, remittance from the United States of foreign born workmen, premiums paid to foreign insurance companies and various other items, but perhaps the most important of all, the flow of securities and the interest and dividends paid upon them to foreign holders. If we had all the items in the visible and invisible balances of trade they would, of course, balance to a cent, but we lack accurate information upon so many of the items that we cannot even strike a balance by difference, representing some single unknown difference.

It is no less than a public calamity that we do not know how the ledger stands at this tremendously critical juncture. If we had this information we could do with confidence much that we may now shrink from doing even as an experiment. What is left us in our ignorance is merely to endeavor to guess how new items will be added to the ledger in the future. We expect our merchandise imports to be decreased, and we hope that our merchandise exports will be increased. Obviously we cannot expect settlement in gold. From the resumption of specie payments in 1879, through the year 1896, we had net gold exports of $130,000,000, being unable, to that extent, to retain the gold we had plus our own current production. From 1897 to date we have had net gold imports of $290,000,000, and so greatly did the tide turn in our favor that we cannot export any further change of importance, which would bear any measurably important relation to our merchandise movement, seeing that of late our annual merchandise movement has been measured in billions, more than two billions of exports and one and a half billions of imports.

Further prospective changes in the additions to our ledger account are reductions in the expenditures of American tourists abroad and in payments of freight charges to foreign vessel owners. With an increase in the favorable balance in merchandise, in what item is the final settlement to be made? Obviously, in the return of our securities held abroad, or in our purchase of foreign securities. By as much as our securities are returned, by so much will interest and dividend payments to foreign holders be reduced, thus adding annually to the amount that must be liquidated.

It has became well recognized in recent weeks that for foreign countries, particularly South American countries, to buy our goods, their projects must be financed. The financing can no longer be done in Europe. Thus far the current thought seems to be that this constitutes a painful necessity, one that we may not be able to meet. Instead, the view should be that this constitutes a welcome opportunity. The trends of trade should be such as to enable us to do this financing, and gradually to become, instead of a debtor nation, an investor nation. Occasionally our mining and metallurgical experts have gone forth from the country and upon developing a prospect in some foreign land have gone to England or the Continent for the funds necessary to develop it. Obviously the expert's standing in the foreign money marts has been less secure than that of foreign experts, dealing with their own countrymen. A new era in the progress of the United States has now arrived, and the American expert who develops opportunities for profitable devolpments in new countries should be able to find the needed capital at home.

American bankers, who have been so woefully narrow minded as not even to ascertain the volume of American securities held abroad, should reform instantly and post themselves as to what is going on in the world. Wonderful opportunities lie before them as to development in South America and elsewhere, and the trends of commerce in the next few years are going to place in their hands large funds for which it will be their duty to find profitable investment. If the opportunities are properly grasped, confidence in the future of American industry and finance will operate very largely to deter foreign holders from returning our securities to us. Such as are offered at bargain prices should be gladly bought. The question should not be how we can avoid buying them, but how we can buy them to our profit, or become so prosperous that they will not be offered. Courage, rather than fear, should be the spirit in which the problem is attacked.

# Readers' Views and Comments

### The Dependence of Industries on Chemistry

*To the Editor of Metallurgical & Chemical Engineering:*

SIR:—"It is, however, unfortunately to be feared that a very large number of lines of manufacture will probably have to depend upon the chemical industry for advice and technical assistance."

What horrid treason is this that rears its head in the editorial pages of *Metallurgical and Chemical Engineering,* of all places? Is it a misfortune to be obliged to depend upon the "chemical industry"? That is a question I cannot answer. But I can speak for a company that depends very largely upon the chemical *profession,* and to those who are facing a similar fate I send a word of cheer and encouragement. It is not a fate so sad as to be unendurable; in fact one grows to like it, though shirt-sleeved plant managers tear their hair and declaim that "a lot of damn high-brows are running the company."

More seriously speaking, will it not be a very good thing for American industry if, owing to the exigencies of the European war, the rule of chemical reason is substituted for the rule of thumb? And will not the same circumstances lead to the perfection of many processes that have not been made "commercially available" heretofore because it was easier or cheaper to depend upon Europe?

Notwithstanding all of the above, the writer perfectly appreciates the whimsical sarcasm of the sentence quoted above from your September editorial on The European War.

D. T. PIERCE.

The Barber Asphalt Paving Company,
Philadelphia, Pa.

### Railroad Electrification as a Relief of Economic Stresses

*To the Editor of Metallurgical & Chemical Engineering:*

SIR:—We all know and are keenly and painfully aware that this is a time of stress even in the United States. But fortunately our people are sinking individual differences and exhibiting a spirit of co-operation and there is true leadership by our big men, who rule not by divine right of natal succession but by the noble divine right of ability. To enable some such men to consider an idea of mine which I trust will be practicalized in some way for common good, I submit to the perusal of your readers the following proposal and argument thereupon.

Public financial opinion is right fearful and apprehensive about three things in main. These are the disposal of the cotton crop, the copper industry, and the possibility that several billion dollars' worth of railroad securities will be dumped on our stock market. Other disturbing factors are small compared with the above big three. In 1893-6, municipalities put unemployed artisans to work on the public roads. These men were not bums but good, earnest men, who wished to work. My idea is that we should adopt a similar scheme—only in a scientific, efficient, and national manner—that is, that by energetic methods we should start next spring the electrification of such portions of our railroads as are clearly to be benefited thereby.

Competent electrical engineers state that in cases where there is great density of traffic or steep grades or heavy train loads the electrical method is the economical method. The same way of steel will carry more people and goods and it is not good engineering economics to put a 2000-kw power house on wheels. Fortunately there have been tried out several systems of electrification of trunk lines, and it is not a hazy issue, but one definite and worked out. My scheme would be to start a general electrification of our steel highways, give honest labor to honest people, and build up a much-needed permanent public improvement.

The railroads, shipper and people are in this province controlled and dominated by the Interstate Commerce Commission. This judicial administratory board fixes rates and adjusts differences. It has been well argued that this board should set its seal of approval on all emissions of railroad securities.

Should such a plan as I have outlined be proposed and the electrification of our large trunk lines start in a comprehensive and intense manner, and should the Interstate Commerce Commission allow the emissions of securities bearing a high rate of interest and with liberal provisions for amortization and depreciation due to advance in the state of art, and such increase in rates as would justify such an expansion, the good effects would be incalculable and as widespread as a rain from heaven in time of drought, which falls on the just and on the unjust.

The copper mining, smelting, and refining industry would flourish. The business of fabricating copper and the electrical industry would revive. The steel and iron trade would be helped. Our energy that might go to waste would be put in useful permanent form.

If such securities ware made safe investments by care and intelligence, and if some of them were so strong that they were legal for savings banks, the money would flow in an endless chain, provided such people as were benefited kept their mental equilibrium.

The collateral problem of our country is to prevent waste not so much by stern necessity as by wisdom and thrift. If we can hold together in spirit, we can emerge from the crisis far stronger than we entered it. High rates of interest will draw out capital from its hiding and keep gold in the United States. Just now the banks are borrowing money at 3 per cent from the Government and loaning it to the people at from 8 per cent to 10 per cent. Good business indeed both for people and the banks, provided the banks put credit in safe hands and the people can earn enough with the capital to pay the increased rates.

This national electrification of railroads must be conditioned on high rates of return. This limitation is in line with the theory propounded and exposited in *Metallurgical and Chemical Engineering* that applied science has opened up as it were a new virgin country where profits are large and usufruct of capital and intelligence is great.

The scheme that I propose is not a chimerical one, at least its benefits would not be ephemeral. Of course, I know that I have elaborated it and elucidated it in the roughest sort of pencil sketch. But put on the drafting board in clear and precise form, it would be a magnificent plan of commercial engineering.

WOOLSEY MCA. JOHNSON.

Hartford, Conn.

### Cost Accounting and the Work of Accountants

*To the Editor of Metallurgical & Chemical Engineering:*

SIR:—In reply to Mr. Ernest G. Ashby's discussion of my article on metallurgical cost keeping, I believe that in the main we agree except as to the title of the employee who calculates the cost data.

It might be inferred from my article that this should fall on the engineer. This is not my intention. There should be someone whose duties are to keep cost data available to the executive, to enable him to deal in detail with his problem. This man should preferably be both an accountant and an engineer. This is usually impossible. If he is an accountant, he should give such cost data as may be prescribed by the engineer, superintendent, etc., and not by the auditor or office force.

The vital point of the entire matter, to my mind, lies in the unit system. Then the particular unit used becomes paramount. Not many systems carry milling costs on any unit basis, except the per ton basis. This unit is based on the number of tons milled. For example: A mill handles 500 tons of ore through the stamps in twenty-four hours. Say 400 tons of this is then slimed in the tube-mills. Is the cost of tube-milling calculated as it should be on the 400-ton basis, or is it wrongly calculated on a 500-ton basis?

The foundation of efficiency is the largest accomplishment for the least expenditure. The words "largest" and "least" are the superlative degrees of comparison. Therefore, costs must be expressed in units capable of comparison to be of any value to the executive. For instance: In the 1913 report of the Alaska Treadwell Gold Mining Company it is stated that pumping costs 10 cents per ton of ore milled. From this simple statement, can anyone state whether that pumping was efficiently done or not? From a cost analysis point of view this should be stated in gallons-feet. To say that pumping costs 10 cents per ton of ore milled is meaningless and worthless and in itself gives the engineer or superintendent no idea of the efficiency of the work.

I admit that the above figure is sufficient for the stockholder, but it does not indicate the efficiency of the pumps to the superintendent.

Naturally these results can be dug out of any system of bookkeeping, but it is my experience that when this is necessary they are never dug. These facts should not only be readily obtainable, but they should show on the regular reports so that any sudden change manifests itself at once.

As usual, an accountant cannot accept any set of figures that do not check to the cent. I still maintain that cost keeping contains errors in spite of the most rigid system, but as long as they allow comparisons, the errors are negligible.

In considering costs, as stated above, comparisons are the vital point of all systems. Halbert T. Gillette in his "Hand Book of Cost Data" goes as far as to say:

"Since cost keeping has as its primary object the reduction of costs, since comparison of results secured by different men or different machines or different methods are necessary, it follows that standard wages and standard prices of materials must be used. It may happen that on one job the cement may be purchased at different times at prices ranging from $1.20 to $1.50 per barrel, and that common laborers may receive from $1.50 to $1.75 a day. In comparing unit costs a standard price of cement should be assumed as $1.30 per barrel and a common labor standard wage as $1.50 per day. Then comparisons become possible. A bookkeeper cannot assume any rate of wage or any price; he must give the actual wage or price. A cost keeper usually finds it desirable to use standard wages or prices which approximate the average, or actually are the average."

The cards shown in my article are merely one form for obtaining this data on a unit basis. Even more than unit measurements are necessary, according to Gillette:

"Cost keeping records should state conditions, such as weather, distance of haul, etc., which are essential to interpretation of results. Sketches showing design of structure should form part of permanent cost records. Such things are entirely foreign to bookkeeping, and if placed upon bookkeeping records simply serve to confuse them."

I agree with Mr. Ashby that the accounting and engineering departments must work together, but I object to the accounting department determining what cost data the engineering department shall use. This may not be so in Mr. Ashby's case, but I am certainly warranted in saying that in most cases the engineering department must accept the cost data as given to them.

JUSTIN H. HAYNES.

Denver, Colo.

## Nevada State Mine Rescue and First Aid Meet

*To the Editor of Metallurgical & Chemical Engineering:*

SIR.—The Nevada State Mine Rescue and First Aid Contest, held on the Mackay Athletic Field of the University of Nevada at Reno, Nevada, on Labor Day, September 7, 1914, was of particular interest in several respects. It was the first strictly metal mine meet to be held in the United States, and the first mine rescue meet to employ a mine rescue maneuver.

Prior to this meet, car No. 5 of the United States Bureau of Mines had been touring the State of Nevada, and the miners who paticipated had been trained by Mr. E. Steidle, mining engineer, and Mr. George W. Riggs, first-aid instructor, both attached to this car. They trained sixty-nine miners and ten students of the University of Nevada in mine-rescue work, and one hundred and thirty miners and fiteen students in mine first-aid work. In addition to this, Mr. Steidle gave week-end lectures on mine rescue and first aid, reaching in all some forty-four hundred miners.

The distribution of the men, who were trained in the work, is shown in the following table:

| Mining Districts | Men Trained in Mine Rescue Work | Men Trained in Mine First Aid | Number of Oxygen Breathing Machines |
|---|---|---|---|
| Ely | 10 | 40 | 6 |
| Virginia City | 10 | 10 | 7 |
| Goldfield | 10 | 10 | 6 |
| Tonopah | 24 | 30 | 13 |
| Round Mountain | 5 | 10 | 2 |
| Blair | 0 | 10 | 0 |
| Wonder | 5 | 10 | 2 |
| Fairview | 5 | 10 | 2 |
| University of Nevada | 10 | 15 | 1 |
| Total | 79 | 145 | 41 |

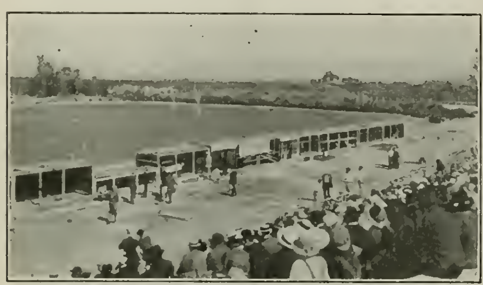
The contest held at Reno was under the auspices of the Engineering College of the University of Nevada, with the co-operation of the U. S. Bureau of Mines, the American Red Cross Society and the Nevada Industrial Safety Association.

In the mine rescue problem a model drift, constructed of timber, lathes and tarred paper, after a design by Mr. Steidle, was employed. This drift was open on the side toward the grand stand, with the exception of one section, which was closed by means of windows, and in which dangerous gases were confined. The drift was 6 in. in height and 260 in. in length and was made up of the following sections: 80 in. of open drift, 20 in. of drift in which a hanging fall was supposed to have taken place and which was, therefore, only 3 in. in height; 20 in. more of open drift, a 40-in. gas and smoke chamber with an inclined obstacle in the center, 20 in. of open drift, 20 in. in which a fall was supposed to have taken place and in which an opening 3 in. high was left above the fall, and finally 60 in. of open drift to the face.

The participants were examined by doctors and then tested and adjusted their apparatus and stood a three-minute trial in a small test-house filled with gas and smoke. Then each team in turn entered the model drift to rescue a miner, supposed to be overcome near the face. Stretcher and breathing apparatus were carried for the use of the injured miner, and a life line was used, and all precautions were taken as suggested by the U. S. Bureau of Mines.

The first prize was won by the Tonopah Mining Company's team. The three other competing teams were from the Veteran Mine of the Nevada Consolidated Copper Company; the Tonopah Belmont Development Company, and the Goldfield Consolidated Mines Company.

Eight teams took part in the Miner's First Aid Contest. The problem in this contest was to aid a miner found in a drift, under a fall of rock, in contact with electric wire, unconscious and suffering from numerous injuries. The first prize was won by the McGill Concentrator team of the Nevada Consolidated Copper Company. The other contestants were the Tonopah Extension Mining Company, the Tonopah Belmont Development Company, the West End Consolidated Mining Company, the Goldfield Consolidated Mines Company, the Tonopah Mining Company and the Veteran Mines of the Nevada Consolidated Copper Company. Three teams of University students contested among themselves.



NEVADA STATE MINE RESCUE AND FIRST-AID MEET

The first prizes were a silver shield and a silver loving cup, presented by the Nevada Industrial Safety Association to the winning teams, while the American Mine Safety Association presented medals to the individual members of these teams. The other prizes distributed in these contests included subscriptions to *Metallurgical & Chemical Engineering* and other technical papers contributed by the publishers, and miners' lamps donated by manufacturers.

Francis Church Lincoln.
Mackay School of Mines,
University of Nevada.

## The Non-Ferrous Metal Market

For sixty days the domestic market for non-ferrous metals has been subject to serious disturbance with wide fluctuations in prices. Curiously enough, different metals have been variously affected, to advantage in some cases and unfavorable in others.

**Copper.**—There has been no wholesale market for this metal for some weeks, and no quotations are available. American producers have acted as a unit in curtailing production about one-half, which will practically compensate the loss of the foreign market, and it is expected that the market will be in good shape when business can be resumed on a normal scale.

**Tin.**—Quotations in this market are still nominal, and with an increasing supply have tended to fall off. The fancy prices asked during August have disappeared, and late quotations are about 33 cents, New York.

**Lead.**—This market has remained weak, and the price of 3.90 cents, New York, has been maintained by the A. S. & R. Co.

**Spelter.**—Prices for this metal have receded from the high figures quoted shortly after the war began. Demand has now become slack. A high price of 6.10 cents was reached on August 26, since which time a steady decline has occurred. Latest quotations are about 5.50@5.65 cents, St. Louis, and 5.65@5.70, New York.

**Other Metals.**—Prices for antimony have risen to from 10½ to 12½ cents for various brands. Aluminium is quiet at 20@20½ cents, New York. Quicksilver showed a stiff advance in price, and is quoted at $75@$85 per flask of 75 lb., New York, about double the prices before the war.

## The Western Metallurgical Field

### Smelter-Fume Damage in Salt Lake Valley

Study of the smelter-fume problem and the effect of smelter gases on agricultural crops is being conducted by the companies operating in the vicinity of Salt Lake City, Utah. The result to date is that two of the plants, those of the United States Smelting Co., at Midvale, and the American Smelting & Refining Co., at Murray, are fumeless as far as the discharge of visible gas is concerned. In fact, to a stranger the plants have the appearance of being closed and not in operation. The Garfield Smelting Works, however, situated at the north point of the Oquirrh range, west of Salt Lake City, continues to discharge into the atmosphere the gases from the smelting and roasting furnaces. The same is true of the Tooele plant of the International Smelting & Refining Co., situated southwest of Salt Lake City, on the western side of the Oquirrh mountains.

Both the Midvale and Murray smelters use the Sprague process for neutralizing the sulphuric acid in the gases, and the products are collected in bag houses. This still leaves sulphur dioxide unaffected, and this gas is discharged into the air. Under normal weather conditions the ill effect of smelter fume in the valley has been greatly minimized due to these improvements, but this year the damage has been increased, due to an unusual snow storm which occurred in June. The average quantity of sulphur dioxide in the valley atmosphere south of Salt Lake City is about 0.25 part per million. The highest is one part per million, and this is observed when northwesterly winds blow fumes from the Garfield smelter over the valley. The lowest quantity observed is a trace, and this condition exists when northerly winds clear the valley of fumes. In spite of the improvement in conditions, however, and the effort of the smelters to meet the imposed requirements, there is more or less friction with the farmers, and damage suits aggregating hundreds of thousands of dollars are pending against the smelters. The Murray plant is said to be working under an agreement with the farmers for compensation for damage, and the Midvale smelter is reported to be seeking a legal modification of restrictions whereby it can smelt an increased daily tonnage of sulphide ores.

Some interesting experimental work is being done by the American Smelting & Refining Co., which has purchased a farm three miles north of the Murray plant. This farm comprises 50 acres of ground, and was one of the poorest farms in the valley. It is not only in the zone of possible fume damage, but it contains an undrained area and some alkali spots, and is therefore suited to the study of a variety of causes of poor crops. On this farm the smelting company has erected a laboratory where a corps of experts conduct their studies. Field tests of the effect of different percentages of sulphur dioxide on various growing crops are made, and the results recorded for future use. Studies are also made of the diseases of local crops and of the various insects which affect the yield. These pathological studies already have resulted in the discovery of bacterial and fungus diseases, the effects of which the farmer has attributed to smelter fume.

The attitude of the American smelting company to the farmer is one that should improve relations between the two interests. The experimental farm is being conducted not only in the interest of the smelter, but it serves also as a demonstration farm for the local farmers. The latter are encouraged to visit the farm, and are given instruction by the experts on methods of improving their farm work. They are shown also the effect of various diseases on crops and are taught how to eradicate the troubles which are not due to smelter smoke. Instead of antagonizing the farmers and claiming that no damage is done, the smelter is apparently admitting evident damage, at the same time protecting itself against imposition. It is an odd fact that farmers in the zone of actual damage are most reasonable and easiest to deal with, while those who are outside the zone of damage cause a great deal of trouble. The work of the American Smelting & Refining Co. should go a long way toward creating a better spirit between the contending factions, as well as determining in a scientific way the actual damage of sulphur dioxide, and gaining a basis for settlement of damage claims.

### The War and the Metallurgical Industry

The state of uncertainty which prevailed in the mining and metallurgical industries immediately following the declaration of war in Europe has largely been replaced by a spirit of optimism and assurance that accompanied a calm study of the situation. With the exception of the curtailment in copper production, there have been no serious disturbances in the metal producing centers of the West. The slump in silver was but temporary and due only to the fact that smelters did not know where they were to dispose of their stocks; hence they could not assure the miner a normal price for his silver ore. The Cobalt district in Canada was vitally concerned, but even there the bullion shipments have resumed their normal proportions, and many companies have resumed operations after a short period of non-production.

Up to the present the lead market has not shown the activity or rise in price anticipated by many operators. Nevertheless, according to well informed smelting officials, it is almost certain that lead will show an advance in the near future. In fact, the head of one of the largest smelting concerns is quoted in the public press as saying that the United States is on the eve of a great opportunity in all commercial lines, and has a chance to supply the world with needed metals. Metal manufacturing industries are suggested as a logical development in order to take care of our excess metal production.

As anticipated, the spelter market has enjoyed a prosperous turn. A stimulus has been given to zinc mining, milling and smelting, and such centers as Joplin have experienced a revival of interest such as has not been known for years. Old properties have been reopened; old mills put in commission; dumps leased for operation, and prospecting stimulated.

The United States Geological Survey has shown commendable activity in issuing so promptly various bulletins on our mining and metallurgical industries. One of the most important is *Bulletin* 599, "Our Mineral Reserves—How to Make America Industrially Independent." It contains an inventory of our mineral resources, and gives some details on fuels, metals and non-metallic minerals of commercial importance. In addition to this, numerous press bulletins have been issued giving authoritative comment on the status of the metals.

From the chemical point of view, the situation in the West is most concerned with the supply of cyanide, and the possibility of domestic production supplying the demand. Such as are interested in the prospect of making cyanide we refer to back files of this journal, in which will be found many technical articles dealing with this industry. Particularly in our issues for March and April of the current volume will be found articles on the manufacture of cyanide and cyanamide, the latter product being of immediate interest as a possible source of the former.

Western metallurgical works, as well as custom chemists and assayers, have suddenly found that their dependence on European manufacturers is greater than they had hitherto thought, particularly for chemicals and filter papers. Prices of these articles have increased several fold and the supply is at present limited. Among other articles affected by the war are graphite, barytes, manganese, tin, arsenic, antimony, radium, potash, zinc dust and flint pebbles. In the case of some of these and other materials, we have been dependent on Europe for supplies in quality as well as quantity, and the present situation emphasizes the importance of developing as far as possible our own resources along these lines. Time will be required to get new industries started, and even then our manufacturers must give consideration to the possibility of maintaining their markets after conditions in Europe return to normal.

Among the large copper companies, Utah Copper Co. will pay the usual dividend for the quarter ending with September. Chino has reduced the rate from 75 cents to 50 cents for the current quarter, and Ray Consolidated and Nevada Consolidated have passed the dividends.

### Pneumatic Flotation Process

New methods of accomplishing ore flotation are being rapidly developed, and a wide variety of means used to accomplish the purpose. One of the most interesting as well as successful methods is that of using air as the agitating and froth-producing medium. Plants using this method have been installed by the General Engineering Co., of Salt Lake City, Utah, at the National mill, in Idaho, the Magma, Miami and Inspiration in Arizona. The ore is mixed with oil and water and fed into a separator which consists of a rectangular cell having an inclined false bottom covered with fabric. Compressed air admitted into compartments below the false bottom passes upward through the fabric and is divided into innumerable small bubbles which form a froth 12 to 18 inches deep in the cell. Mineral concentrate rises with this froth and overflows the sides of the cell, while gangue flows down the inclined bottom and is discharged. If desired, the first cell can be used as a rough concentrator, and the valuable product re-treated in another cell. The products from several roughers could be combined on one cleaner. Pine oil has been found to be a good floating medium, and is used in the oil mixture in varying proportions.

### Camp Bird and Santa Gertrudis

These two English companies controlling the Camp Bird mine in Colorado and the Santa Gertrudis in Pachuca, Mexico, have become suddenly involved in financial loss due to the collapse of commercial enterprises in which the former chairman of the companies, Mr. A. M. Grenfell, was interested, and in which funds of the mining companies were invested or on deposit. In an official statement issued by Mr. H. C. Hoover, who has accepted temporarily the chairmanship of both companies, it is announced that the probable total loss will not be as great as at first anticipated. Camp Bird probably will sustain a loss of $50,000, and Santa Gertrudis $135,000. Both companies, however, are sound mining and metallurgical enterprises, and will not be seriously crippled by these losses. The Santa Gertrudis mill has been closed owing to disturbances in Mexico, but the Camp Bird is in operation.

### Butte & Superior

It is reported that July operations at this property in Montana showed an improvement in milling results. The former recovery of 90% was maintained and at the same time the grade of zinc concentrate was raised from 51.73% in the first quarter to 55% early in July. These concentrates are sold on a 50% zinc basis, and any improvement over that grade brings a premium, just as a deficiency entails a penalty. The property is now operating under normal conditions, producing and treating about 1000 tons of ore per day.

### Model Town at Anaconda

It is reported that the Anaconda Copper Mining Company, through its subsidiary, the Deer Lodge Valley Farms Company, is to establish a model town for the employees of the smelter at Anaconda. The new settlement will be known as Opportunity. It is located east of Anaconda in the Deer Lodge Valley, where a large acreage has been divided into five and ten acre tracts on which the smeltermen may establish a home and garden plot. The Anaconda trolley system will be extended to the new town, and the Anaconda company will assist the new settlers in every way to establish themselves in comfortable homes. The scheme includes the establishment of legitimate forms of amusement for adults and children, but saloons are barred.

## The Iron and Steel Market

The great uncertainties attending any attempt to forecast even roughly the effects of the European war, as referred to in our report a month ago, have been only slightly reduced by the progress of time. It was impossible to judge of the prospects by precedents, for of precedents there were absolutely none. For judgment at the present time we have nothing but the concrete experience of two months and that is very far from conclusive.

The buying power of the so-called neutral or consuming countries has been vastly reduced. Financing of new projects has practically ceased, and funds are usually lacking even for making purchases for current and everyday consumption. When funds are available it is difficult to purchase exchange or to establish London or New York credit. Despite the fact that Germany, France and Belgium are physically unable to export any considerable quantity of iron and steel, and Great Britain's manufacturing resources are somewhat curtailed, the demand from neutral markets is curtailed so much more that Great Britain is unable to sell all the goods she can produce. To the United States there has come little inquiry from neutral markets, and the small iron and steel export trade the United States was conducting just before the war, amounting to about 140,000 tons a month, has not been fully restored, and may not be for several months.

The early idea that the chief desideratum for an iron and steel export trade was ocean-carrying facilities, was quite promptly exploded. Exports to Canada, which move entirely by rail, have been greatly reduced. The fact that war has throttled buying capacity, rather than shut off supplies, is indeed proved by the remarkable case of the United States itself. As indicated in the review a month ago, a first effect of the war was to encourage buying in a few quarters, by fear of possible scarcity later, but even at the outset this tendency was slight. The more important trend then mentioned, as to a stoppage of new projects requiring financing, is now being felt in full force, and even purchases for ordinary current requirements are greatly reduced. The total volume of buying in the United States is considerably diminished.

Steel mill operations are necessarily decreasing, but the decrease lags behind the decrease in buying through, there having been on order books a moderate accumulation of business. While the steel mills operated at nearly 70 per cent. of capacity in July, at the close of September they are operating at not more than 50 per cent and all the prospects are that the rate will diminish further, and probably to the smallest percentage of capacity that has ever obtained in the history of the American steel trade.

The more distant future of the American steel industry cannot be the subject even of intelligent guessing. An illustration of the wide uncertainties may be of interest. Through the refinements of modern practice the amount of coal involved in the production of a ton of finished steel has been very greatly reduced and by reason of this the iron and steel developments in the great Minette ore district have been rapid in recent years. These developments have been on both the German and the French side, but when the war is over there is every reason to believe that practically the whole district will be either German or French. If German, that country will probably include Belgium also, and Germany would then be a close second to the United States in iron and steel production instead of a relatively distant second. If the territory falls to France, that country will rank second and Germany third, while England, with no change within her borders, will drop from third to fourth place.

The producing section which would be transferred from the German colors to the French has found its market chiefly in Germany, but would then have to find a new market. There is no reason to suppose that France would experience much increase in domestic consumption, and that country would therefore probably become in time a keen competitor in the export trade. In circumstances of which this illustration is one suggestion, it seems quite impossible to make guesses as to what place the American iron trade will occupy in the world's commerce after the war, while it does seem reasonable to conclude that during the war no spectacular demand for iron and steel can arise in any part of the world.

### Pig Iron

The pig iron market has been stagnant. Buyers have been extremely conservative and purchases have been few. Actual consumption has decreased and shipments of merchant furnaces have been curtailed. As the producers must necessarily be conservative there has been a decrease in production, and the merchant furnace output of pig iron is the smallest for a long time, with prospects of further reduction. The price situation having already been well liquidated there have been no material declines. The eastern market has advanced a trifle and the Chicago market has lost a little ground.

Current quotations are partly nominal: No. 2 foundry, f.o.b. Birmingham, $10 to $10.25; delivered Philadelphia, $14.70 to $14.95; f.o.b. furnace, Buffalo, $13 to $13.50; f.o.b. furnace, Chicago, $13.25 to $13.50; at valley furnaces (90 cents higher delivered Pittsburgh), Bessemer, $14; basic, $13; No. 2 foundry and malleable, $13 to $13.25; gray forge, $12.50 to $12.75. Ferromanganese has weakened after the early excitement, and prompt shipments from American stocks are quoted at about $85, shipments from England in limited quantities being quoted at $80, f.o.b. Baltimore.

### Steel

The large mills advanced their quotations on billets and sheet bars early in September, and have since been quoting $21 and $22 respectively. Small lots are occasionally offered by the smaller mills at somewhat lower figures, while deliveries on current contracts are also at a much lower level. In the minds of buyers at least there is serious question whether the present quoted prices will ever be the subject of extensive trading. Rods are about $26, Pittsburgh. A few sales have been made for export to England at a slightly higher level, while domestic contracts now being filled average less than $25.

### Finished Steel

There have been scarcely any changes in quoted prices on finished material.

The quoted prices are not being seriously tested, as new buying is practically at a standstill, and specifications on old contracts, made before the recent advances, are materially reduced.

Prices named below are regarded as representing the market, such as it is, and f.o.b. Pittsburgh unless otherwise stated.

Rails, standard sections, 1.25c. for Bessemer, 1.34c. for open-hearth, f.o.b. mill, except Colorado.

Plates, tank quality, 1.20c.

Shapes, 1.20c.

Steel bars and bands, 1.20c., base; steel hoops, 1.30c., base.

Iron bars, 1.25c., Pittsburgh; 1.17½c., Philadelphia; 1.07½c., Chicago.

Sheets, blue annealed, 10 gage, 1.45c.; black, 28 gage, 2.00c.; galvanized, 28 gage, 3.00c.; painted corrugated, 28 gage, 2.20c.; galvanized corrugated, 28 gage, 3.05c.

Steel pipe, ¾ in. to 3 in., 80 per cent off list.

Steel boiler tubes, 3½ in. to 4½ in., 72 per cent off list.

Wire nails, $1.60, base; smooth fence wire, 1.40c., base; galvanized fence wire, 1.80c., base; galvanized barb wire, 2.00c.

Standard railroad spikes, 1.45c., Pittsburgh; 1.50c., Chicago.

Structural rivets, 1.55c.; boiler rivets, 1.65c.

Cold rolled shafting, 66 per cent off list.

Chain, ⅜ in. proof coil, 3.05c.

---

**An alloy for welding copper and nickel**, patented in this country by Canzler and Samesreuther (1,103,482) consists of copper, phosphorus and a small percentage of silver.

**Light, strong castings**, adapted for use where high temperatures are employed, can be made of 85 to 87 per cent aluminium, 9 to 11 per cent zinc, 2 to 4 per cent lead and 1 to 3 per cent of a strengthening element such as copper or nickel. The formula is patented by C. P. Van Gundy (1,098,137). Tellurium is suggested as a strengthening element in aluminium alloys, in patent (1,102,618) granted to Samuel Wein.

**Deposits of phosphate** near the Red Sea have been largely developed in the last two years, according to the Egyptian *Gazette*. The mines are worked by a British company, and the product is exported. The rock contains 65 per cent or more of tri-calcium phosphate. Other Egyptian deposits also are being exploited under concessions. The total output of phosphate rock in 1913 was a little over 100,000 tons, almost all of which came from the Red Sea deposits. Shipments are made mainly to Japan. The local demand for raw phosphate is almost negligible, and superphosphate is imported. Projects are being considered, however, for the local manufacture of superphosphate.

## Program of Niagara Falls Meeting of the American Electrochemical Society

The twenty-sixth meeting of the American Electrochemical Society will be held in Niagara Falls from Oct. 1 to 3, with hotel headquarters at the Clifton Hotel.

*Thursday, Oct.* 1.

9:30 a. m. Reading and discussion of papers at the Clifton Hotel.

The Constancy of Base-Metal Thermocouples as Affected by Their Microstructures: O. L. Kowalke.

The Evaporator and the Power Problem in Electrochemical Plants: Otto Mantius.

On Electrometric Titrations: Henry Ziegel.

The Reproducibility of the Copper Electrode: Frederick H. Getman.

The Source of Impurities in Cathode Copper: Lawrence Addicks.

The Electrolytic Determination of Nickel: N. Judson Marsh.

Experiments on the Quantitative Determination of Radium: Herman Schlundt.

2 p. m. Excursion to Foster's Flats.

8:30. Smoker in Clifton Hotel.

*Friday, Oct.* 2.

9 a. m. Excursion to plants on the American side. Among those to be visited will be the power houses, the Acheson Graphite Company (who will show some features not hitherto exhibited), the Niagara Alkali Company (under usual reciprocal restrictions), Spirella Corset Company (triple-plating department), etc.

2 p. m. Reading and discussion of papers at the Clifton Hotel.

Silicidized Carbon: Silfrax: F. J. Tone.

The Electrolytic Insulation of Aluminum Wire: C. E. Skinner and L. W. Chubb.

Electro-Percussive Welding: C. E. Skinner and L. W. Chubb.

On the Formation of a Badly Conducting Film on a Copper Anode in Copper Cyanide Solution: W. Lash Miller.

Tin Salts of Mineral Acids: F. C. Mathers and B. W. Cockrum.

Electrodeposition of Lead from Lead Lactate and Lead Formate Solutions: F. C. Mathers and B. W. Cockrum.

Electrodeposition of Lead from Lead Acetate Solutions: F. C. Mathers.

7 p. m. Dinner at Clifton Hotel, to be followed by an illustrated lecture: "The Physical Nature of Color," by C. E. Kenneth Mees (director of Research Laboratory, Eastman Kodak Company).

*Saturday, Oct.* 3.

9:30 a. m. Symposium on "The Practical Side of Electrochemical Investigation," at the FitzGerald Laboratories (Highland and Whirlpool Avenues, Niagara Falls, N. Y.). This symposium will consist of a number of informal demonstrations of apparatus, methods, and materials used in electrochemical investigations, or as electrochemical aids to chemical investigations. The symposium will proceed throughout the day, with an intermission at 1 p. m., when a complimentary luncheon will be tendered by the Niagara Falls members at the Cliff Distributing Company's substation, Highland and Whirlpool Avenues.

In the evening there will be an informal rendezvous at the Niagara Club.

The privileges of the Niagara Falls Country Club will be extended to members throughout the meeting.

Mr. F. A. Lidbury, works manager of the Lidbury Electrochemical Company, is the president of the American Electrochemical Society

## The Effect of Steam Upon Magnesite Brick or Calcined Magnesite

BY R. H. YOUNGMAN

Carbonate of magnesia or magnesite is found chiefly in Greece, Austria-Hungary, Africa, India, and in California in the United States. The deposits of Greece and California are of the white massive character and as a rule of very pure quality. They are not as suitable for refractory purposes in metallurgical processes as the Austro-Hungarian magnesite, on account of composition and high cost of preparation. The white magnesites are used principally in caustic form as flooring cement and for the manufacture of carbonic acid gas, the carbonate as mined containing approximately 50 per cent of $CO_2$ (carbonic acid gas) which may be driven off for this purpose at comparatively low temperature. A few refractory brick are made from white magnesite, but difficulties of manufacture and high cost render the demand very slight.

It is with the Austro-Hungarian magnesite that the users of magnesite in this country are most concerned. The material occurs in a crystalline formation and is gray in color with tinges of brown. In comparison with the white magnesite it differs in composition and formation. The chemical composition is the most important difference. Comparative analyses of the two kinds of magnesite, calcined, are as follows:

| | Austro-Hungarian | White |
|---|---|---|
| Silica ($SiO_2$) | 2.75 | 2.50 |
| Alumina ($Al_2O_3$) | 0.50 | 0.25 |
| Iron oxide ($Fe_2O_3$) | 7.00 | 1.00 |
| Lime (CaO) | 2.50 | 2.25 |
| Magnesia (MgO) | 87.00 | 93.00 |
| Loss on ignition | 0.75 | 1.00 |

The impurities in the Austro-Hungarian render it less refractory, and it will frit more readily at operating temperatures, which is a very important property, especially in open-hearth practice in building the bottom and repairing the slag line. In the calcined form, for commercial uses, Austro-Hungarian magnesite has a rich brown color and white magnesite is either white or a very light brown, depending upon the thoroughness of calcination.

The chief uses of magnesite brick are in open-hearth steel furnaces, copper converters, reverberatories and settlers, and electric furnaces. Their use is spreading considerably where strong basic slags, mill cinder and strongly metallic slags are encountered, such as the bottoms of forging, heating, and welding furnaces.

It is an interesting fact, and one of importance to all users of magnesite, that when subjected to the action of steam, magnesite in calcined form, or even the most thoroughly burned brick, will hydrate, similarly to the action of calcined lime when water is added. This hydration takes place to equal degree in all brands of magnesite brick made in the United States or Europe. The effect of the hydration is disintegration to an almost impalpable powder. It does not seem to bear any relation to the content of lime or other impurities, as the tests showed the same results for Austro-Hungarian as for white or very pure Grecian magnesite.

Tests were conducted by placing brick in a steam-tight cylinder and subjecting it to steam at 100 lb. pressure for a period of two hours, all brick tested showing hydration to the same degree, though it is reasonable to conclude that the action would be somewhat retarded under lower pressure or less severe conditions.

Difficulties of this nature have been experienced in open-hearth furnace bottoms by laying the brick and magnesite bottom over a bed of refractory materials mixed with water. Upon heating up steam is formed and the bottom may be very badly damaged by hydration of magnesite.

This fact, which has not been well established until recently, no doubt accounts for a number of similar troubles which have occurred in years past. It also explains cases of disintegration of burned magnesite brick which have been in contact with steam leaking from coils or steam-heated floors used in manufacturing magnesite brick. It should be made a matter of common knowledge, therefore, so that users of magnesite will be able to guard against trouble of this kind, especially during the initial heating period.

Harbison-Walker Refractories Co.,
Pittsburgh, Pa.

## The Determination of Phosphorus in Scheelite Concentrates

BY E. W. HAGMAIER

The two most common methods for analyzing scheelite concentrates are:

Place 1 gram of the concentrate in a porcelain evaporating dish or casserole and add 75 cc of concentrated hydrochloric acid, and from time to time add potassium chlorate until the tungsten is all oxidized. This will require from 3 to 4 grams. If one does not want to use hydrochloric acid and chlorate, then aqua regia may be used, and the sample is taken to dryness. Take up with dilute hydrochloric acid (½), warm and loosen as much of the tungstic acid from the sides as is possible. Add 15-20 cc of cinchonine solution, some paper pulp, and let stand about half an hour before filtering. Filter and wash with dilute hydrochloric acid to which some cinchonine has been added.

The residue which is tungstic acid, silica, and some iron is burned in a platinum crucible, and then treated with a few drops of sulphuric acid and several cc of hydrofluoric acid and the silica volatilized. The excess sulphuric acid is driven off and the crucible weighed. A sodium carbonate fusion of the residue is then made and the melt is leached out of the crucible with water, and boiled. The tungsten is in solution as sodium tungstate and the iron which was held by the tungsten is precipitated as carbonate. This is filtered and washed with hot water, and burned in the original crucible, this weight deducted from the former weight gives $WO_3$.

In order to determine the phosphorus in these concentrates it is necessary to treat another sample as above, but omit the addition of cinchonine before filtering and in washing. The writer's experience has been that some of the tungsten washes through, necessitating a second filtration after the filtrate has been concentrated. This takes considerable time as the filtrate must again be evaporated to a low bulk after the second evaporation before the phosphorus is precipitated.

It occurred to me that the phosphorus could be precipitated from the cinchonine filtrate by using cerium chloride as a precipitant for the phosphorus.

To the cinchonine filtrate from the scheelite add 10 cc of cerium chloride solution (1 gram cerium chloride, 25 cc hydrochloric acid, 250 cc water), make the filtrate neutral with ammonium hydroxide, boil five or ten minutes, and filter, washing with hot water. Dissolve the precipitate off the paper with hot (1-1) nitric acid and precipitate the phosphorus with molybdate.

The following results were obtained on synthetic mixes with WO 65-70 per cent, $Fe_2O_3$ 4-5 per cent and phosphorus 0.100, 0.150, 0.300, 0.200.

| Phosphorus found | No. 1 | No. 2 | No. 3 | No. 4 |
|---|---|---|---|---|
| | 0.083 | 0.152 | 0.296 | 0.195 |
| | 0.087 | 0.144 | 0.293 | 0.195 |
| | 0.094 | 0.147 | 0.303 | 0.193 |
| | 0.096 | 0.147 | 0.298 | 0.203 |

Babcock-Hagmaier Laboratories,
Lackawanna, N. Y.

# Grinding Ore for Cyanidation: A Suggested Modification for All-Sliming Practice

BY W. J. PENTLAND

The following comments are intended to apply to "all-sliming" practice of crushing, and principally to the silver ores of Mexico that call for more extended treatment than do the ordinary docile gold ores of the United States.

It is common custom that the treatment of ore is controlled by what is found necessary for the satisfactory treatment of the most refractory part, even though a large part may not call for that treatment with its consequent cost.

When we follow the incoming ore through the mill, sampling and testing at each successive step, we find that a part separates easily and quickly, gives up its valuable metal with less time of contact and agitation, and often with weak solution. We find that the remaining part also separates easily and quickly, but is of denser and more compact nature, needs longer time of contact and agitation, and also needs grinding and regrinding.

This separation takes place in the classifiers that follow the primary grinders—stamps, chilean mills, or whatever type the primary grinder may be.

### Different Character of Sand and Slime

The first part—the overflow from the classifier—we may call "slime." It is usually the softer and more friable part of the ore; was not made by any effect of the crushing, but was simply released; and contains but very little material that could be considered as having been made in the crushing operation. It constitutes anywhere from 30 to 60 per cent, by weight, of the total ore crushed.

The second part—the discharge from the classifier—we may call "sand." It is usually the harder and tougher part of the ore; is made up of all sizes of particles, from the finest to the coarsest that have passed through the screen; needs regrinding to bring it somewhere near the size of slime to release its valuable content; and requires longer agitation to extract the metal. It constitutes anywhere from 70 down to 40 per cent, by weight, of the total ore crushed. But even if it constitutes only 40 per cent of the total ore, the 100 per cent of the ore will be subjected to the treatment determined as necessary for this 40 per cent. Area of tanks and buildings, stronger cyanide solution, power for agitation, repairs and renewals, all have been provided and are being used on the maximum treatment basis for the total ore, when but a half or less of it requires anything like such treatment.

### Special Treatment for Refractory Part of Ore

It may be argued that it would be another complication to make a separation of these two parts of the ore; but that argument would not apply, for the separation *is always made*. It is made at the classifiers; and moreover, one of the parts is always thickened for the immediately following regrinding, in fact is too thick for agitation. This is the "sand" part. It does not matter that this part may be subsequently ground to the same size as the slime; it is still sand in everything but size; it is dense and compact; and even though it may not call for stronger solution, it will call for longer time of contact and agitation. It is separated; it is thickened; it is ground to its ultimate size; and it should be given the treatment necessary for itself before it is again combined with the slime. Or rather, it should be given such separate agitation that when later combined with the slime, the strength of solution and time of contact sufficient for the treatment of the slime will also be sufficient to *complete* the treatment of the sand.

We would not recommend separate decantation, because the slime alone would be found difficult to settle readily if the sand were not combined with it to assist settlement; moreover, there would be no advantage in decanting the two parts separately as the process would be identical with each.

### Agitator in Tube Mill—Classifier Circuit

The mill arrangement on this basis would place the sand agitators following the tube mills. The pulp would have to be elevated; but it has to be elevated anyway, either by some elevator, pump, or air-lift, to the classifier; or by the classifier itself and a big scoop on the tube mill, if a closed-circuit system be followed. And if it were the custom to send the pulp direct from the tube mill to the thickener, the pulp could flow into and from the agitator set at a low level, without consuming any appreciable amount of fall in addition.

In any case, the top of the agitator would be such that the overflowing pulp could flow to the classifier. The closed circuit would still be maintained; the pulp sufficiently ground would have received its due agitation and would join the overflow of slime from the classifier, and go on to the thickener. The insufficiently ground pulp would be discharged from the classifier and returned to the tube mill, again passing through the agitator.

The elevating of the pulp to the top of the agitator would not be any great addition to what is already being done, and could be accomplished easily by placing an air-lift *inside* the agitator, or in the last of a series of agitators, thereby taking care of the submergence question. Under conditions of present practice we have a classifier set close up to a tube mill, with launders running to and from it on the ragged edge of insufficient fall, and a great, big, unwieldy scoop on the head of the mill. Under the proposed scheme we might have a small, light, cheap scoop on the head of the mill, the discharge flowing by gravity directly into an agitator or a series of them, with an air-lift placed *inside* the last agitator to lift the pulp the few feet necessary to return it to the classifier. As between the two arrangements, give me the latter with the air-lift.

The depth of the agitator can be placed below the discharge of the tube mill, excavating if necessary; or the agitator can be placed in a distant part of the mill if immediate space be not available close by, the pulp elevator being placed before or after the agitator as conditions would indicate.

If the tube mill should discharge into the agitator by gravity, there would also be the advantage of the latter acting somewhat as an equalizer: if the charge were carried a few inches low, the air-lift could be stopped if the classifier had to be shut down temporarily; if the crushing also had to be stopped, the air-lift could be stopped, but the agitation could continue.

Also, but not least, if concentration were practiced, the sand would carry all the concentratable product; it would be in ideal form, thickened but easily diluted to the desired point. The air-lift at the overflow of the agitator could elevate the pulp to such height as would permit of its being passed over tables and still returned to the classifier or to the thickener as might be desired. And as most concentrating tables also classify pulp tolerably well, that sand which had been "slimed" in passing through the tube mill could be cut out and sent directly to the thickener; only the sand really needing regrinding being returned to the classifier.

### Scheme Applicable to All-Sliming Method

These ideas apply to any plant making an "all-slime" product; whether using cones, Esperanza, Dorr, Akins, or any other classifier; Trent, Dorr, or any other agitator; continuous decantation as Dorr has arranged it, or as Trent works it.

With Dorr's arrangement of precipitating the overflow from the first thickener in continuous decantation, this overflow would be enriched by the metal dissolved from the agitated sand; the metal dissolved from the slime in later agitation would still go around through the batteries and ultimately be recovered from the thickener overflow solution as now arranged.

The combined pulp would still pass through the usual first thickener; but the agitators following would be designed to give only the conditions necessary to make the extraction from the slime, this being only a part of the treatment formerly given to the whole combined pulp. The sand agitators would be of capacity for only half or so of the total ore; special treatment could be given this refractory part of the ore; and the solution used on it would be substituted by new solution by the time it reached the second agitators, which of itself would be a benefit.

We believe that this suggested arrangement offers a number of possible advantages: (1) less equipment; (2) weaker solutions and lower chemical consumption of cyanide; (3) earlier recovery of valuable solution; (4) lower grade of solution to be displaced at the tail end of the plant, with consequent reduced loss of dissolved metal; (5) lower mechanical loss of cyanide, because of weaker solutions; (6) lower power consumption to the extent that the agitation in the second agitators would be only for the period found necessary to make extraction on the slime. It is true that the use of power for agitating the sand has been transferred from one set of agitators to another, but the saving lies in not agitating the slime any more than its needs demand.

### Importance of Strength of Solution and Time of Contact

Strength of solution and time of contact seem to stand out as the most important factors in agitation. Volume of solution and substitution of new solution in extended time of agitation, are also factors of importance, but not to the extent of the first two.

It seems to have been determined in general practice that where strong solution and shorter time of agitation give equal results in extraction with weaker solution and longer time of agitation, the latter system is the more economical in the end. It would appear that the higher cyanide consumption due to the use of stronger solutions, with less agitation, is more costly than lower cyanide consumption due to lower strengths used, with more agitation and consequent power cost. At least that seems to be general practice; the universal tendency being to endeavor to bring about the use of lower strength solutions, even though it entail longer time of agitation. What every operator the world over is always trying to do above everything else is—reduce the strength of the working solution. He can trace most of his economies effected to this source. He can allow quite a margin in installation, power consumed, and in many other features, if he can but accomplish a lowering of the strength of his solution. A great saving is always made in the cyanide consumed chemically; solutions do not foul so easily and quickly; and the mechanical loss of cyanide is always less with weak solution as there is less to be displaced before discharging the final tailing.

If operators would consider more the mechanical losses that occur all through the plant in addition to that represented in discharged tailing, they would thereby locate a lot of the trouble experienced in making bullion recovery tally with assay returns.

If any operator takes the faith cure and persuades himself that his shift bosses do not overflow tanks and launders; do not waste solution around pumps and in pipe and valve repairs; do not permit leaks from the bottom of tanks to seep away; he will have to study advanced mathematics to enable him to figure out a method to explain away discrepancies in final results.

The weaker the strength of the working solution the less loss from all these mechanical troubles; also, the dissolved valuable metal circulating around a plant would be less, and the loss from this source would also be reduced.

Proper drainage floors leading all waste to catch basins would recover most of the loss, but how many plants do we find that have all floors cemented, and draining to catch basins?

### Early Recovery of Dissolved Metal

In Dorr's arrangement of continuous decantation he does not precipitate the solution recovered after agitation, but sends it back to the batteries to serve the incoming ore first, and then precipitates it when recovered from the overflow of the first thickener. This is evidently a point evolved to recover the valuable solution as early as possible in the system so that there will be less of dissolved metal to be carried toward the tail end of the plant; and he thereby relieves the decantation tanks of a great part of their most responsible work. At the same time he is putting more dissolved metal into circulation around the plant, and this is subject to the mechanical losses that we have been emphasizing.

With agitation of the sand after regrinding and before thickening, the metal dissolved from this part would be recovered from the overflow of the thickener immediately following. There would, therefore, be no circulating around the plant of this part of the dissolved metal; also, the dissolved metal carried with the pulp from the second agitators to the washing thickeners would be less than ever, with consequent reduction of dissolved metal in the tailing.

The sand being the more refractory, the cyanide for strengthening solution would be added to the head of the tube mill, thus making the tube mill a part of the sand agitating system. This stronger solution would raise considerably the strength of the battery solution that really constitutes the overflow of the first thickener. In all probability this solution accompanying the thickener discharge would still have an excess of cyanide for effecting extraction on the slime. Hence no cyanide would have to be added to the second agitators; weaker solution would be circulating toward the tail end of the plant; and mechanical loss from this source would be reduced.

Another feature that supports this last contention is, that the strengthening of the battery solution in the classifier by the strong solution coming over with the agitated sand, would raise the strength of working solution in contact with the slime while passing through the classifier and the thickener. This would occasion earlier dissolution of metal from the slime, further enrich the thickener overflow and thereby earlier remove more metal from circulation. It would also reduce the work required of the second agitators, and so more than ever reduce the cyanide and dissolved metal to be taken care of at the tail end of the plant.

It may be contended that but few ores are of such a nature that the part we designate as slime would give up its valuable metal under the conditions that we specify. It is a matter of interest that in the Black Hills of South Dakota there are plants operating in which the slime separated at the classifiers is passed through thickeners serving as continuous wash tanks, and *no specific agitation at all* is given this pulp. It gets its agitation while passing through the crushing apparatus. It is of no especial concern at the moment that these Black Hills operators have percolation plants to treat what we here call the "sand" part of the ore. If they should later practice all-sliming they would still separate this same sand as they are now doing, could give it its due agitation apart, and then combine it with the slime and carry out the same treatment that they are now giving the slime.

### Scheme Applicable to New or Existing Plants

The application of this system would present no particular difficulties. In designing a new plant we would have everything more compact and more easily supervised, as the sand agitators and the first thickener would be about on the same level, and close to the tube mills instead of two levels below. Heretofore we have had to concede to the thickener's particular service the fall or depth of its tank, and all the subsequent equipment has had to come below it to make a gravity-flow plant. It is true that with Dorr's arrangement the zinc boxes now come practically on the thickener level or but little below. With our scheme the sand agitators, thickener, and zinc boxes would all come on practically the same level. Below this level would come the combination agitators, and the thickener wash-tanks.

In adding these sand agitators to an existing plant they would have to be placed wherever a location could be found, even at a distance; and it is likely that more elevation would have to be given the pulp, as the distance to and from the agitators would have to be considered in determining the fall of the carrying launders.

This separate agitation of the sand does not involve the use of any particular crushing machinery, the use of any particular classifier, thickener, or agitator, nor the use of any particular decantation or washing system. It would serve only with "all-slime" crushing.

Denver, Colo.

---

**The mineral production of Texas** for 1913 is valued by the U. S. Geological Survey at over thirty million dollars. The state ranks nineteenth among the United States in the value of its mineral production. It ranks second in the production of asphalt and third in production of quicksilver. It holds fourth rank in quantity of petroleum produced. Sulphur production, by methods similar to those used at Sulphur City, La., were begun at Bryan Heights, in Brazoria county, in 1913.

**Imports of artificial dye-stuffs** into the United States have been valued at $10,000,000 annually for each of the past five years. The imports for the year ending June 30, 1914, fell off about 5 per cent in value as compared with previous years. The following table shows the imports for 1914, with the share furnished by Germany.

| | Pounds | Value |
|---|---|---|
| Alizarin and alizarin colors: | | |
| From Germany | 2,593,758 | $833,705 |
| From all other countries | 39,656 | 11,754 |
| Aniline salts: | | |
| From Germany | 2,768,191 | 202,722 |
| From all other countries | 316,276 | 20,006 |
| Indigo: | | |
| From Germany | 7,448,412 | 938,097 |
| From all other countries | 676,799 | 155,129 |
| Coal-tar colors, all other: | | |
| From Germany | ...... | 5,965,537 |
| From all other countries | ...... | 1,275,869 |
| Total values: | | |
| From Germany | ... | $7,940,061 |
| From all other countries | | 1,462,758 |

NOTE—The statistics for indigo include imports of natural indigo from India, which average less than $100,000 worth annually.

---

# The Possibilities of Hardwood Distillation on the Pacific Coast

BY R. C. PALMER

Chemist in Forest Products
Forest Products Laboratory, Madison, Wis

### Introduction

The interest in the wood distillation industry on the Pacific Coast has been confined in the past entirely to the softwoods, Douglas fir, and western yellow pine. Unfortunately, the history of the commercial attempts that have been made to obtain valuable products for these species has been largely a succession of failures, owing to a variety of causes.

The fact that softwood distillation is not a well established industry, the inability to secure commercial quantities of suitable raw material at favorable prices, and the more or less experimental nature of plants that have been erected have been in general the main causes for these failures. The products which these plants attempted to recover from the western softwoods were turpentine, tar, tar oils, and charcoal, and in several cases alcohol and acetate of lime, depending on the process employed.

It is well known that the yields of the three last named products, charcoal, alcohol, and acetate, are considerably less from softwoods than from hardwoods, and that the yield of these products is sufficient to make the distillation of certain species of hardwood a perfectly feasible commercial enterprise.

In view of the importance to other industries on the Pacific Coast, of securing wood-distillation products, particularly charcoal and wood alcohol, without paying freight from plants in the middle western or eastern States, and because of the very limited possibilities of securing these products economically from softwoods, the United States Forest Service conducted investigations during the fall and winter, 1913-14, both at the Forest Products Laboratory, Madison, Wis., and on the coast, to study the feasibility of establishing a small hardwood distillation industry in that locality.

The results of this investigation are summarized in this paper.

### Hardwoods Available

There is a large variety of hardwoods native to the Pacific Coast, including birches, maples, and oaks. There are some fifteen species of oaks alone, besides several imported species such as Eucalyptus, acacias, madrone, etc.

None of the native hardwoods occur in pure stands, however, and very few in large enough stands mixed with the softwoods to make them of importance as raw material for a distillation plant.

From the standpoint of the species with quantities sufficiently centralized only two or three appear promising: (1) the tanbark oak (Quercus densiflora); (2) the California black oak (Quercus Californica), with the scattering "white oaks"* that occur with it—such as Oregon post oak, Chinquapin oak, Canyon live oak; (3) possibly Eucalyptus.

The present investigation has considered only the tanbark oak and the black oaks. It seems probable that Eucalyptus will compare favorably with the oaks as regards yields of by-products, but the quantities available are too small to be considered for the present. Eucalyptus gives an especially high grade charcoal which brings a high price per ton in limited quantities and can, therefore, be best considered only for the production of charcoal.

---

*These oaks occuring in scattered stands as well as a number of hardwoods such as gray birch, Oregon maple, alder, cottonwood, etc., probably all have a value for making charcoal alone where few charcoal kilns can supply the immediate demands of a community. Since softwoods can compete with the hardwoods in the manufacturing of charcoal alone, these hardwoods are obviously eliminated from the list of possibilities.

### Tanbark Oak

Tanbark oak is best known because of the high value of its bark for the production of tannin. However, only the bark is used, and the tree is generally allowed to rot in the woods. Utilizing the wood of this tree after being abandoned by the bark peelers is an economic problem of considerable importance.

This oak occurs principally in the redwood* belts of Mendocino and Humboldt counties, California, forming a band along the inland side of the redwood covering what is called the "Bald Hills." The best stands are not in the main redwood forests, but only on the summits above the redwood, particularly on the inner summits and ridges. Here the trees are most abundant and of large size and running probably as high as 15 to 20 cords of wood per acre; with an average of about 7 to 10 cords.† This stand is light compared to the usual yields of cordwood per acre for distillation plants, but as this same region will be logged for the great redwood forests, there is a possibility of securing the tanbark wood in connection with these logging operations.

The logical place for distillation plants using the tanbark oak is in connection with the redwood lumber mills cutting in this region, and where mills are in the coast towns, thus providing shipping facilities for the products either by rail or water.

### California Black Oak

The California black oak occurs in a much more solid stand than the tanbark oak. The range of this oak is comparatively wide, but the accessible timber is located in a small area of about 40 square miles in Shasta County, California, north and west of the Pitt River, and along its tributaries. This oak occurs in largest quantities on the west slopes and flats of the foothills west of the Sierra Nevada range. It is estimated that in a small area beginning witih Reynolds Basin in the Shasta National Forest, where the stand will average 25 cords per acre, south and west for about 20 miles between the Pitt River and Squaw Creek, there are 300,000 cords of this oak. The black oak would make practically no saw timber, and only very scattered stands of western yellow pine and red and white fir are found with the oak. This species of hardwood from the standpoint of quantity and general characteristics would be available to a distillation plant located at a point on the Pitt River most accessible to the Portland division of the Southern Pacific Railroad.

### Laboratory Tests on Tanbark and Black Oaks

Tests to determine the yields of products from California tanbark and black oaks compared to the species commonly used for distillation purposes, beech, birch, and maple, were made at the Forest Products Laboratory. The results of these tests are given in Table 1. The yields of wood alcohol, acetate of lime, and charcoal from Douglas fir and western yellow pine are also given for comparison.

From the figures given in the table the average yields from beech, birch, and maple are about 1050 pounds charcoal, 192 pounds acetate, and 10.6 gallons crude alcohol per cord. On this basis the tanbark oak would be expected to yield about the same in charcoal, 20 per cent. more acetate, and 8 per cent more alcohol than the species commonly used.

Small trunks of black oak high in sap would give about 5 per cent more charcoal, the same acetate, and 11 per cent less alcohol than the standard species. It is apparent that for the black oak the greater the per cent of sapwood such as in limbs, the higher the yields, since small limbs* give 30 per cent greater yields in charcoal, 40 per cent greater yields in acetate, and 18 per cent more alcohol than beech, birch, and maple. The possibility of securing all black oak as limbs or other forms high in proportion of sapwood would, however, not be great.

TABLE 1—COMPARATIVE YIELDS OF WOOD ALCOHOL, ACETATE OF LIME, AND CHARCOAL, PER CORD* BASED ON LABORATORY TESTS†

| Species | Charcoal | Acetate of Lime | Crude (82%) Wood Alcohol |
|---|---|---|---|
| | Pounds | Pounds | Gallons |
| Beech.............. | 1100 | 185 (Heartwood)††<br>200 (Slabs) | 12 (Heart)<br>11 (Slabs) |
| Birch.............. | 1000 | 205 (Heart)<br>213 (Slabs) | 9 (Heart)<br>9 (Slabs) |
| Maple.............. | 1050 | 183 (Heart)<br>170 (Slabs) | 11 (Heart)<br>11.6 (Slabs) |
| Tanbark oak....... | 1050 | 238 (Heart) | 11.4 (Heart) |
| Black oak.......... | 1100 (Slabs)<br>1400 (Limbs) | 190 (Slabs having high per cent sapwood)<br>270 (Limbs all sapwood) | 9.4 (Slabs having high per cent sapwood)<br>12.4 (Limbs) |
| Douglas fir......... | 800 to 900 | 60 Stumps<br>80 Slabs | 3 Stumps<br>4.3 Slabs |
| Western yellow pine. | 750 to 850 | 60 to 80 | 2 to 4 |

*One cord is taken as 90 cubic feet of solid wood containing 15% moisture.

†Results are average of several distillations, each distillation on about 80 pounds of wood.

††In a number of species it has been found that the higher the proportion of sapwood the higher the yields of acetate of lime. For this reason the different forms of wood are given.

From the laboratory tests, therefore, both the tanbark and black oaks, especially the former, compare very favorably with the species or hardwood used in other localities.

### Commercial Tests

The laboratory tests on black oak were followed by a commercial distillation of 7 cords at the wood distillation plant of the Noble Electric Steel Company, Heroult, California. This plant was not designed for hardwood distillation, but had previously operated on western yellow pine with practically no success.

Unfortunately the plant was not especially fitted for the best results from hardwood distillation and the black oak tested consisted of split cordwood from large trees and contained practically no limb wood or forms high in proportion of sapwood.† The commercial yields obtained are given in Table II. The yields per cord from one test (2 cords) of a mixture of scrub oaks and canyon live oak classed as "white oak" are also given.

TABLE II—YIELDS PER CORD COMMERCIAL DISTILLATION OF CALIFORNIA BLACK OAK

| Species | Alcohol, Crude, 82% | Gray Acetate of Lime | Charcoal |
|---|---|---|---|
| | Gallons | Pounds | Pounds |
| Black oak .. | 8.7 | 117 | 1140 |
| White oak | 8.7 | 135 | 1090 |

The commercial yields on black oak indicated about the same charcoal, 8 per cent less alcohol, and 23 per cent less acetate of lime than the laboratory tests. These data are, however, not strictly comparable because of the difference in the character of the wood tested in the laboratory, and in the plant.

In spite of lower yields obtained commercially than was expected, the possibilities of commercial operation are favorable, even if better yields are not obtained with better wood and plant conditions.

---

*Forest Service Bulletin 75 "California Tanbark Oak."

†According to estimates in Forest Service Bulletin 75, the total stand is about 675,000,000 board feet, which would be at least 500,000 cords of wood suitable for distillation

*These figures are based on cords of equal volume of solid wood. In actual practice a stacked cord of limbs would contain much less volume than split wood which would reduce these proportions.

†In addition to difference in form the commercial wood was either very green or badly water soaked at the time of making the tests.

## General Commercial Conditions

### QUANTITY OF RAW MATERIAL

The possibilities of establishing a hardwood distillation industry on the Pacific Coast must be confined to fairly large and well concentrated blocks of timber suitable for cordwood. The destructive distillation of hardwoods for the manufacture of charcoal, wood alcohol, and acetate of lime, is a highly technical industry requiring rather expensive equipment of a standard design. For this reason, sufficient raw material should be available to insure 15 to 20 years life of a plant.

A plant with a capacity of 36 cords per day is about as small as can be economically operated. This would require a stand of hardwood containing from 150,000 to 225,000 cords of wood and, in addition, it is evident that the material cannot be scattered over too wide an area.

### COST OF BUILDING AND OPERATING ECONOMIC PLANTS

The cost of building and equipping efficient hardwood distillation plants would be from $2,500 to $3,000 per cord per day capacity. A 36-cord plant would, therefore, cost between $90,000 and $110,000.

This applies to the standard oven type of plant in which each oven or retort holds from six to eight cords and the wood is carried in small cars, each carrying about two cords. Such a plant would be completely equipped to manufacture gray acetate of lime and wood alcohol suitable for denaturing grain alcohol.

On account of the wide variation in cost of labor, freight rates, etc., in different localities, and because of different conditions of efficiency or supervision, etc., cost data on the operation of hardwood distillation plants cannot be given which will apply to all cases.

The relative weights of the different items of the cost of operating plants are, roughly, as follows:

| | |
|---|---|
| Raw material (wood in retorts) | 40 to 50 per cent of total cost |
| Labor | 15 " 25 " " " " " |
| Fuel for distilling and refining | 10 " 20 " " " " " |
| Maintenance (repairs overhead, etc.) | 15 " 25 " " " " " |

The raw material is by far the largest single item of expense and especial attention to economical handling of wood is, of course, essential. Every time a cord of wood is handled it adds about $0.50 to its cost. The average cost of wood in plants in the Middle West and East is about $3.50 per cord in the retorts. The wood on the Pacific Coast would probably cost more than this as (1) it is generally less accessible, (2) it is not as well concentrated, and (3) the cost of labor is higher. Where eastern labor costs $1.75 per day, the same labor will cost $2.25 per day in California.

The choice of fuel for distilling the wood and refining the products is an important consideration. Probably the best condition as regards fuel is in case the plant is operated in connection with a saw mill where ample wood waste is available for this purpose which would otherwise be sent to the trash burner. The cost of fuel is then only the cost of conveying the waste to the retorts and maintaining the fire in the fire boxes. This cost should not be over $1 per cord of wood distilled. Where wood waste is not available in California, crude oil is probably the best fuel. The cost per cord would be, however, appreciably higher than wood waste fuel, costing probably from $1.25 to $1.50. These fuel costs are not much higher than in other places using comparable fuels.

In spite of the increase in cost of operation due to higher labor and wood costs in California over other localities the total cost of operation should apparently not be over $9.50 per cord as compared to about $8 to $8.50 per cord in other localities.

### VALUE OF PRODUCTS

Higher costs of operation combined with lower yields of products as in the case of black oak would appear to be too great a handicap for profitable operation on this species of wood, but while the yields of alcohol and acetate from black oak may be somewhat lower than from beech, birch, and maple, the charcoal is slightly higher, and in addition charcoal is generally worth from 40 to 60 per cent more in California than in the localities where the charcoal from the standard distillation species is sold.

The effect of this difference in charcoal value in bringing up the total income from products is seen in the following calculation:

YIELDS FROM BEECH BIRCH, AND MAPLE, AND VALUE OF PRODUCTS IN EASTERN STATES AT PRESENT TIME

| | | | |
|---|---|---|---|
| 10.5 gal. 82% alcohol at 26c | = $ 2 73 | or 8¼ gal. 95% at 47 | = $ 3 87 |
| 195 lb. acetate at 1.5c | = 2 92 | | = 2 92 |
| 1050 lb. charcoal at $7 per ton | = 3 67 | | = 3 67 |
| Total | $9 32 | | $10 46 |

YIELDS FROM BLACK OAK AND VALUE OF PRODUCTS IN CALIFORNIA

| | | | |
|---|---|---|---|
| 8.7 gal. 82% alcohol at 26c | = $ 2 26 | or 6.75 gal. 95% at 47c | = $ 3 17 |
| 147 lb. acetate at 1.5c | = 2 20 | | = 2 20 |
| 1140 lb. charcoal at $10 per ton | = 5 70 | | = 5 70 |
| Total | $10 16 | | $11 07 |

In the case of tanbark oak there is every reason to believe that the yields of alcohol and acetate will be greater rather than lower than beech, birch, and maple.

Ten dollars a ton is a minimum figure for charcoal when sold for domestic fuel in coast states. Its average value is probably nearer $15 a ton for this purpose. The market value of alcohol and acetate cannot be expected to be higher than in other localities since the same markets are supplied in both cases.

### MARKET FOR PRODUCTS

*Charcoal.*—The possibilities of creating a demand for charcoal for domestic fuel are apparently excellent, especially in California, where both wood and coal are very high. In other localities where the manufacturer has done a little advertising, charcoal has supplanted wood blocks and kindling wood for making quick hot fires.

With the development of metallurgical processes another large market may be created for charcoal, although for this purpose the value is generally less than for domestic fuel.

Charcoal is difficult to ship for long distances, so the markets will necessarily always have to be somewhat local.

*Acetate of Lime and Alcohol.*—There is at present no acetate of lime used on the Coast, but home production of acetate might encourage the establishment of a small acetic acid industry to supply the white lead manufacturers.

The total consumption of wood alcohol on the Pacific Coast is at present about 1200 barrels or 60,000 gallons. A small part of this is consumed in wholesale drug houses but the largest proportion is used for the denaturing of grain alcohol. This alcohol is at present being supplied from eastern plants at 8 cents freight cost over New York quotation. There seems to be little doubt but that any plant in California could successfully compete in this home market.

With the opening of the Panama Canal the largest opportunity for marketing both alcohol and acetate of lime is with the export trade.

The following tables, taken in part from the yearly report of the U. S. Bureau of Foreign and Domestic Commerce, 1912, show the exports of these products to various countries from the United States for several years past:

EXPORTS OF ALCOHOL (GALLONS)

| Country | 1908 | 1909 | 1910 | 1911 | 1912 | 1913 |
|---|---|---|---|---|---|---|
| Japan....... | 280 | 2,350 | 49,829 | 36,490 | 50,302 | |
| Canada...... | ..... | 209 | 4,539 | 2,486 | 30,799 | ....... |
| Germany..... | 781,000 | 568,000 | 654,000 | 974,000 | 815,000 | ....... |
| Netherlands.. | 45,000 | ....... | 173,000 | 471,000 | 102,000 | ... |
| All Europe... | 1,937,000 | 1,085,000 | 1,269,000 | 1,912,000 | 1,474,000 | 1,837,000 |

EXPORTS OF GRAY ACETATE OF LIME (POUNDS)

| Country | 1908 | 1909 | 1910 | 1911 | 1912 | 1913 |
|---|---|---|---|---|---|---|
| Japan... | ........ | 2,200,000 | 3,600,000 | 5,800,000 | 5,300,000 | ........ |
| Belgium... | 26,200,000 | 25,800,000 | 27,100,000 | 22,900,000 | 28,100,000 | ........ |
| Germany... | 17,200,000 | 18,800,000 | 14,900,000 | 16,700,000 | 16,700,000 | ........ |
| Netherlands... | 10,800,000 | 11,600,000 | 10,500,000 | 15,300,000 | 11,500,000 | ........ |
| United Kingdom. | 2,100,000 | 1,700,000 | 1,800,000 | 2,800,000 | 600,000 | ........ |
| Canada....... | 50 | 241,000 | 15,000 | ....... | 126,000 | ........ |
| Total....... | ....... | 66,550,000 | 63,687,000 | 70,191,000 | 69,235,000 | 80,597,000 |

Japan probably offers the best opportunity for export trade for wood alcohol. The wood alcohol consumption is, however, rather small. At present both these products go to Japan via the Suez Canal. Eastern plants will, no doubt, compete in this market through Panama, but in that case the European markets will be as open to any plant in California as the Japanese markets will be accessible to plants in Michigan or Pennsylvania.

A 36-cord plant would produce in a 300-day year, approximately 75,000 gal. of 95 per cent alcohol, and between 1½ and 2 million lb. of gray acetate.

From the standpoint of the present market conditions it is doubtful, therefore, if the establishing of more than one or two small plants in California would be advisable.

---

**Lead sheets and pipes** of American manufacture are in demand in European countries, according to the *Daily Trade and Consular Reports* issued by the Department of Commerce at Washington. Drawn steel tubes and lap-welded tubes of iron or steel also are needed.

**A copper-leaching plant** of 20-tons daily capacity is reported to have been placed in operation at the Mason Valley smelter, at Thompson, Nevada, for the treatment of certain oxidized ores from the Yerington district.

**Flotation of copper ores** according to a new process attributed to John D. Fields is to be tested at the mill of the Ohio Copper Co., at Lark, Utah, and at some other copper concentrators.

**"Salting" of Radium Ore.**—One or two instances have recently come to light in which it is thought that an attempt was made to give a fictitious radium value to uranium-bearing material. Suspicion exists that uranium residues from which radium has been extracted, have been mixed with carnotite, thereby raising the grade of the material as to uranium, so that when the radium value of the ore was determined from its uranium content, as has been customary, it would appear much higher than it is. The possibility of deception by this practice may result in abandoning the indirect determination of radium in favor on the more accurate and direct electroscopic measurement.

**Diamonds** have become a drug on the market since the European war broke out. The Diamond Syndicate has terminated its contract with the De Beers company in South Africa, and the mines of the latter have been closed.

# Indeterminate Cases in Mixing Ores for Calculation of Furnace Charges

BY REGIS CHAUVENET

## Mixing Ores to Secure a Required Percentage of Any Constituent

Before taking up the actual calculation for slag composition in a mixture of several ores, it may be well to show how to mix ores of given composition in order to secure a certain (required) percentage of any given constituent.

First, let there be two ores; the problem is so simple that it hardly requires elucidation. The requirement is easily formulated and the formula reduced to the following rule, viz.:

*Take weights of the two ores in inverse ratio to the differences between their assays and the (required) assay of the mixture.*

*Example.* (*a*). Mix two ores containing, respectively, 40 per cent and 8 per cent of a given constituent, so that the mixture shall contain 16 per cent.

(1) The larger per cent less the required per cent is $40 - 16 = 24$.

(2) The required less the smaller per cent is $16 - 8 = 8$.

Now take weights of the two ores *inversely* as these figures, i.e., take eight parts of No. 1 and twenty-four parts of No. 2. (In this instance reducing to simpler ratio, as $8:24 = 1:3$, take one part of No. 1 and three parts of No. 2.)

*Proof.* 100 lb. of No. 1 contains.....40 lb. metal
300 lb. of No. 2 contains.....24 lb. metal

400 lb. mixture contains.....64 lb. metal.

Then 64 is 16 per cent of 400, as required.

If there are three ores to be mixed there is no definite solution, unless one of the three happens to contain the given constituents in just the required proportion. In that case it is evident that the proper proportions of the other two ores having been adjusted, any weight whatever added of the third ore will not change the percentage of the given metal.

However, if no one of the three contains the required percentage, then if Nos. 1, 2 and 3 represent respectively the minimum, intermediate and maximum percentages, and since the required percentage must obviously be greater than in No. 1 and less than in No. 3, we have an "indeterminate" mixing problem, *"if all three ores are to be used.* For the required percentage must lie either between Nos. 1 and 2 or between 2 and 3, so that it can never be necessary to use all three ores, so far as the mere obtaining of this percentage is concerned.

By limiting the weights of one lot of ore to a certain figure, or by stipulating a certain proportion as between certain classes of ore, we may reduce the problem to a "determinate" one. Cases of this kind are exceptional, but it is well to have a ready method for figuring on them.

*Example.* (*b*) We have three ores assaying 39, 24 and 8 respectively. (N. B. It makes no difference whether the figures represent percentages or ounces to the ton.) We want 16 (per cent or ounces) in mixture. Obviously this may be obtained either from Nos. 1 and 3 or from Nos. 2 and 3. But suppose we are compelled to use both 1 and 2 and the latter in twice the proportion of the first.

What proportions of the three ores in the mixture? Take 100 lb. of No. 1 as the basis.

---

[1] Calculation of Furnace Charges, by Regis Chauvenet. This Journal, Jan., Feb., Mar., Apr., and June, 1912.

[2] Ibid.

| | |
|---|---|
| 100 lb. of No. 1 contains................ | 39 |
| 200 lb. of No. 2 contains................ | 48 |
| —— | — |
| 300 lb. of mixture contains............. | 87 |

The mixture then contains $\frac{87 \times 100}{300} = 29$ per cent or ounces. The mixture now constitutes one element of the calculation, and we proceed to mix it with enough of No. 3 to get the final required figure (16).

$$29 - 16 = 13 \text{ and } 16 - 8 = 8.$$

We have then to take 8 units of the "mix" and 13 units of No. 3.

Suppose we have to make up an "even" weight of the total mixture. Go back to original ore parts, and proportionate to (say) 1000. We find for the three required parts in 1000 lb., No. 1, 127; No. 2, 254, and No. 3, 619 lb. This may be proved as in the former example, ex. gr.

$$\left.\begin{array}{l} 127 \times 0.39 = 49.53 \\ 254 \times 0.24 = 60.96 \\ 619 \times 0.08 = 49.52 \\ \overline{1000} \qquad\quad \overline{160.01} \end{array}\right\} \text{160 is 16 per cent of 1000.}$$

### Mixing Ores for a Definite Slag

These little "mixing" cases are thrown in here merely as incidental to cases of mixing ores for a definite slag. We have shown an "equation" method in previous articles,[1] for any two ores and a limestone, illustrating that unless the problem is impossible for sheer lack of proper constituents in the data, it presents no especial difficulty. We now put the case of three ores and a limestone. The latter is assumed in all the examples to contain:

| | |
|---|---|
| Silica ...................... | 10 per cent |
| Lime (CaO) ............... | 50 per cent |

As this is intended for an arithmetical illustration only, we simplify it by making the supposed analyses ideal to an extent not to be expected in nature. The ores are supposed to have been "cleared" of the matte, i.e., that has been taken out (by calculation) and nothing is given in the analyses except what enters the slag.

An indeterminate case is one in which several mixtures may bring about the required condition i.e., a slag of the stipulated composition.

Generally, any problem to which there are several answers, or an indefinite number of answers, may be called indeterminate.

Algebraically, an equation with two unknown quantities ($x$ and $y$) with no further condition or equation to assist, is called indeterminate. The same term may be applied to two equations involving three unknown quantities, or, in short, to any set of equations presenting a greater number of unknowns than there are equations.

There are cases in which although but one rational answer is possible the statement is nevertheless indeterminate in form. These are not considered. They could hardly occur in metallurgical practice. Discussion of a few cases in which several mixes alike meet the general requirement, will be sufficient. In accordance with our precedents, there are made extremely simple.

*Example.* (a) We have three ores analyzing, as to slagging constituents, as follows:

| | $SiO_2$ | Bases | Lime (CaO) | |
|---|---|---|---|---|
| Ore No. 1...... | 50 | 30 | .. | per cent |
| Ore No. 2...... | 40 | 20 | .. | " " |
| Ore No. 3...... | 30 | 10 | .. | " " |
| (Limestone as above) ....... | 10 | .. | 50 | " " |

*Ore* charge is to be 1000 lb. Requirement for the slag as below, viz:

| | |
|---|---|
| Silica ........................ | 50 per cent |
| Bases from the ore mixture.. | 25 " " |
| CaO from the limestone...... | 25 " " |
| | —— |
| | 100 " " |

(We drop our usual practice of assuming 100 lb. *for one of the ores.* Note that the charge of 1000 lb. does not here include the flux (limestone).

As no one ore is fixed in weight, but the sum total of the three alone is a fixity, the weight of any one becomes an "unknown."

Let $100x$, $100y$ and $100v$ represent respectively the weights in pounds of ores 1, 2, 3 and of the limestone. The last ($100v$) is inserted to give generality in form since $v$ may be determined without formal calculation.

The constituents are now represented by the same figures as their respective percentages, all with the unknown letters annexed, as below. (Reason for taking $100x$, etc., instead of $x$ is to obviate necessity of fractions. Coefficients for $x$, $y$ and $z$ are now taken directly from table of analyses.)

| | $SiO_2$ | Bases | CaO |
|---|---|---|---|
| No. 1 ............. | $50x$ | $30x$ | ... |
| No. 2 ............. | $40y$ | $20y$ | ... |
| No. 3 ............. | $30z$ | $10z$ | ... |
| Limestone ......... | $10v$ | ... | $50v$ |

This method of setting forth the constituents entering into a slag calculation has been given at length in this journal in former articles.[2] It suffices to call attention to the fact that we may now select expressions for silica, base or lime directly from the analyses as written above, i.e., with the respective letters annexed, remembering that the total quantity of any one constituent of the charge is represented by $100x$, etc., as stated above.

There are three equations on the conditions.

$$100x + 100y + 100z = 1000 \text{ (Or; } x + y + z = 10\text{)} \qquad (1)$$

$$30x + 20y + 10z = 50v \text{ (i.e., bases = CaO)} \qquad (2)$$

$$50x + 40y + 30z + 10v = 30x + 20y + 10z + 50v \qquad (3)$$

Equation (3) expresses the condition that the silica equals all the bases, lime included. No. 3 reduces to $x + y + z = 2v$.

Hence by (1) $2v = 10$ and $v = 5$. Limestone therefore $(100v) = 500$ lb.

### Quantity of Lime Independent of Proportions of the Three Ores

This shows that the lime addition is independent of the proportions of the three ores. This is no general proposition for similar cases, but merely an incident in the present conditions. It often happens, however, that some fact like the above (viz: independence of the lime addition) is first discovered analytically.

The limestone being thus found to be the same for any possible mixture under the conditions, reduce the remaining equations. We find:

$$\text{(a) } x = 5 + z \text{ and (b) } y = 5 - 2z$$

Here is the "indeterminate" condition, viz: two equations with three unknown quantities. Algebraically, this indicates an indefinite number of correct solutions. In fact, it is a case in which the two unknowns in these final equations become variables. Assume a value for one of them, the other must, of course, assume a corresponding value. Discussion of the maximum and minimum values of each of these unknowns is exceedingly simple. As $z$ occurs in both of the equations, let us start with it.

(a) shows that 0 is a possible value of $z$ (minimum).

(b) shows that with $y = 0$, $z$ has its maximum value of 2.5

Substituting in (a) we find $x$ has a maximum value of 7.5 and a minimum value of 5. (That is, the ore No. 1 may run from 750 down to 500 lb., but not less.)

Substiuting in (b), we find that $y$ has a maximum value of 5, minimum of 0. We could eliminate $z$, getting $2x + y = 15$. Then $y = 0$ makes $x = 7.5$, and any value for $x$ less than 5 violates the data. But this would save no time, as $z$ would have to be brought in again.

Tabulating these various cases, and writing the values multiplied by 100 so as to represent actual pounds of ore or flux, we have

| | Maximum | Minimum |
|---|---|---|
| Ore No. 1, lb...... | 750 | 500 |
| Ore No. 2, lb...... | 500 | 0 |
| Ore No. 3, lb...... | 250 | 0 |

(*Limestone, always* 500 *lb. for any mixture.*)

We see, then, that ore No. 1 must always be used, and with it, some portion of No. 2 or No. 3 or both, according to the weight of No. 1 taken. Any violation of the equations violates also the slag condition, as may easily be shown.

Take maximum of No. 1; No. 2 now goes to its minimum, i.e., zero. But No. 3 goes to its maximum, 250 lb.

Take minimum of No. 1; No. 3 now goes to its minimum (zero), while No. 2 goes to its maximum, 500.

In all other cases, viz.: with No. 1 somewhere between maximum and minimum, all three of the ores enter the mixture. Assume any value between limits for $x$ then substitution in equations (2) and (3) gives values to $y$ and $z$.

*Examples under each ease.*

(*a*) Ore No. 1: take maximum weight of same. Calculate bases and silica. (No. 1 = 750 lb.; No. 2 = 0; No. 3 = 250 lb.; total = 1000 lb.)

| | $SiO_2$ | Bases | CaO | |
|---|---|---|---|---|
| From ore No. 1..... | 375 | 225 | ... | lb. |
| From ore No. 2..... | 0 | 0 | ... | " |
| From ore No. 3..... | 75 | 25 | ... | " |
| Limestone .......... | 50 | ... | 250 | " |
| | 500 | 250 | 250 | " |

(*b*) Ore No. 1: take minimum weight.

No. 1, 500 lb.; No. 2, 500 lb.; No. 3, zero.

| | $SiO_2$ | Bases | CaO | |
|---|---|---|---|---|
| From ore No. 1..... | 250 | 150 | ... | lb. |
| From ore No. 2..... | 0 | 0 | ... | " |
| From ore No. 3..... | 0 | 0 | ... | " |
| From limestone .... | 50 | ... | 250 | " |
| | 500 | 250 | 250 | " |

(*c*) Ore No. 1; take *any weight intermediate* the maximum and minimum.

No. 1, 700 lb.; No. 2, 100 lb.; No. 3, 200 lb. These figures are found by substituting in (a) and (b).

| | $SiO_2$ | Bases | CaO | |
|---|---|---|---|---|
| From No. 1........ | 350 | 210 | ... | lb. |
| From No. 2......... | 40 | 20 | ... | " |
| From No. 3......... | 60 | 20 | ... | " |
| From limestone ..... | 50 | ... | 250 | " |
| | 500 | 250 | 250 | " |

In the last case we assumed, arbitrarily, that we should take 700 lb. of No. 1. But as this figure is between the limits (750 maximum and 500 minimum) it must lead to correct results under the conditions. Note that these conditions are satisfied in every case—i.e., silica always equal to bases, and CaO always equal to bases from the ores. The problem is thus reduced to finding maximum or minimum weight which can be used of three given ores. It could be used to increase or decrease the use of certain ores, according to supply or cost.

Novices in algebraic statement often attempt to get as many equations as there are unknown quantities, in an indeterminate case. For instance, another equation which in reduced form would read:

$$5x + 4y + 3z = 45$$

could be taken to represent the condition that silica = twice CaO. But this is already implied in the equations above, so that in eliminating $x$ we merely regain the old form: $y = 5 - 2z$.

### Calculation Based on Assumption of One Hundred Pounds of Principal Ore

In calculating furnace charges for slags, we prefer to assume 100 lb. for the leading ore, and adjust the other additions to that figure. Texts on slag calculation differ in this respect; there are those who seem to prefer an assumption for *weight of total charge* (i.e., all the ores and fluxes, but not including the fuel).

In the following example we adopt the method that has always seemed both easier and more logical to us. It is, of course, a mere matter of convention. But it is such an easy matter, having figured for the 100-lb. basis, to pass to any other basis, that the method assuming total charge for the basis of calculation is no longer in favor.

If in any calculation of this kind a value with minus sign should be obtained it is, aside from errors of computation, an indication of the fact that you are attempting to reconcile incompatibles. Inspection of analyses will often show in advance that no mixture of the given components can give the desired result.

To illustrate the above, take the following case: We have three ores with analyses of slagging constituents annexed as below:

| | Silica | FeO | Other bases |
|---|---|---|---|
| Ore No. 1...... | 40 | 10 | 30 per cent |
| Ore No. 2...... | 10 | 60 | 10 " " |
| Ore No. 3...... | 20 | 10 | 40 " " |

Assuming that these can be mixed for "self-fluxing," i.e., without the addition of any limestone, we demand a slag of the following composition, viz.:

Silica, 40 per cent. Iron oxide (FeO), 35 per cent. Other bases, 25 per cent.

As basis for the ore mixture, take 100 lb. of No. 1 ore. Let quantities of ores Nos. 2 and 3 be represented by $100x$ and $100y$ respectively.

We have now as expressions for constituent parts the following:

For $SiO_2$; $40 + 10x + 20y$
For FeO ; $10 + 60x + 10y$
For base; $30 + 10x + 40y$

The 40, 35, and 25 required percentages reduce to ratio 8, 7 and 5.

$7(40 + 10x + 20y) = 8(10 + 60x + 10y)$

Ratio of $SiO_2$ to FeO.

$5(10 + 60x + 10y) = 7(30 + 10x + 40y)$

Ratio of FeO to bases.

The equations present no difficulties in elimination, but having solved for $x$, which we find = 0.45 +, we find on substituting that *y comes out minus.*

Inspection of the analyses, in fact, shows that there is so much iron oxide in No. 2 ($100x$) that we cannot simultaneously get iron low enough and base high enough, while No. 3 ($100y$) has so high a base that it upsets all attempts to adjust the three to the requirements. A trial of any two of the ores will show that the condition is incompatible with the composition.

*Example* (*b*). We give another example of the "indeterminate." The limestone, as indicated in the first place, remains the same, viz.: $SiO_2$ = 10 per cent, CaO = 50 per cent.

| | $SiO_2$ | FeO | |
|---|---|---|---|
| Ore No. 1 | 40 | 10 | per cent |
| Ore No. 2 | 30 | 20 | " " |
| Ore No. 3 | 10 | 30 | " " |

Calculate in this case, the ore charge on the basis of 100 lb. taken of No. 1. *Slag to have composition:* $SiO_2 = 30$ per cent, $FeO = 40$ per cent and $CaO = 30$ per cent; the latter, of course, has to come entirely from the limestone. As before, let $100x =$ lb. of No. 2 ore, $100y =$ lb. of No. 3 ore, and $100z =$ lb. of limestone. Collect expressions for $SiO_2$, FeO and CaO as usual, and equate according to the slag condition.

We cannot obtain more than two independent equations. A few paragraphs back we said that novices often try to get as many equations as there are unknown quantities. Let us try here. We have:

$$\text{Total } SiO_2 = 40 + 30x + 10y + 10z$$
$$\text{Total FeO} = 10 + 20x + 30y$$
$$\text{Total CaO} = 50z$$

Since silica is to equal lime we equate these expressions (1) as FeO is to CaO as 4:3 we put that ratio into (2). Finally as $SiO_2$ is to FeO as 3:4 we embody that ratio in (3).

$$40 + 30x + 10y + 10z = 50z \qquad (1)$$
$$3(10 + 20x + 30y) = 4 + 50z \qquad (2)$$
$$4(40 + 30x + 10y + 10z) = 3(10 + 20x + 30y) \qquad (3)$$

These equations are all divisible by 10. It will be convenient to keep (1) for reference in the form:

$$4 + 3x + y = 4z \qquad (1)$$

The fallacy is in supposing that we have three independent conditions. But, in fact, one condition is implied by the other two.

To divide by 10 and eliminate $x$ is a very trivial operation. We then arrive at the amazing equation:

$$1 = 0$$

or some other absurdity according to the elimination. In short, having made a false assumption and tried to prove it true, we land nowhere.

Throwing away equation (3) we return to (1) and (2) which with $z$ eliminated gives us:

$$4y - 9x = 17.$$

Here $y$ and $x$ are increasing functions. As $y = 0$ gives *a minus value for* $x$ it is not possible. But $x = 0$ gives $y = 4.25$ as minimum value for $y$.

This indicates that using 100 lb. of ore No. 1 (as assumed) we may discard ore No. 2 entirely, and take 425 lb. ($100y$) of ore No. 3. The limestone is found by using the reference form of equation (1) above. We get $4z = 8.25$; $z = 2.062$, i.e., limestone ($100z$) 206.2 lb. Our slag figures then as below, ore No. 2 being omitted.

| | $SiO_2$ | FeO | CaO | |
|---|---|---|---|---|
| From ore No. 1 | 40 | 10 | ..... | lb. |
| From ore No. 2 | 42.5 | 127.5 | ..... | " |
| Limestone | 20.6 | ..... | 103.1 | " |
| | 103.1 | 137.5 | 103.1 | |

10 per cent of 425 = 42.5; 30 per cent of 425 = 127.5 (on ore No. 3).

10 per cent of 206 = 20.6; 50 per cent of 206.2 = 103.1 (on limestone).

This proof is perfect, for the three figures 103.1, 127.5, and 103.1 are exactly in the ratio required, i.e., 3:4:3.

How is it that the silica of the limestone adjusts itself to the summation? Answer: It was adjusted in the original statement, and having been involved in equation (1) no subsequent transformation could take it out.

Still retaining our supposition of 100 lb. of ore No. 1 as the basis of our mixture, how can we work in any portion of ore No. 2, if it be desired to make use of that material? Evidently by taking more of No. 3 than the minimum 425 lb. That is, if we assume a value for $y$ greater than the minimum, $x$ becomes a positive quantity. Let us, for example, assume that we shall add 500 lb. of No. 3 ($y = 5$). Substitute in the indeterminate expression, we get $x = 0.3333$ or $100x = 33.33$ lb. Take equation (1) again, and putting $y = 5$ and $x = 0.3333$ 1/3 we find $z = 2.5$; that is, limestone = $100z = 250$ lb. Our charge being now as follows, viz.: No. 1 = 100 lb., No. 2 = 33.33 lb., No. 3 = 500 lb., limestone = 250 lb., the proof consists, as before, in taking the percentages as shown by analyses on these weights.

| | $SiO_2$ | FeO | CaO | |
|---|---|---|---|---|
| Ore No. 1 (100 lb) | 40 | 10 | ... | lb. |
| Ore No. 2 (33 1/3 lb.) | 10 | 6.7 | ... | " |
| Ore No. 3 (500 lb.) | 50 | 150 | ... | " |
| Limestone (250 lb.) | 25 | ..... | 125 | " |
| | 125 | 166.7 | 125 | " |

Again the proof is perfect, for 125:166.7:125 = 3:4:3.

Thus, on the assumption that we use a portion of No. 1 ore, we find that up to a certain point we are restricted to the use of No. 3 only, but having passed that minimum we must use all three. Indeed there is but the one mix that excludes No. 2, viz.: 100 lb. of No. 1 and 425 of No. 3. Try to use less than 425 of No. 3 and we at once get irreconcilable results. This is not worth illustrating.

Finally to complete this discussion of the indeterminate, we may omit No. 1 ore, and recast our mixture, still getting an adjustment that will bring about the required slag. Leaving out No. 1 then, and assuming 100 lb. of No. 2 as our basis, keeping $100y$ for No. 3, and $100z$ for limestone, the problem passes out of the indeterminate class and becomes quite simple, i.e., with but a single solution. We have $SiO_2 = 30 + 10y + 10z$; $FeO = 20 + 30y$; $CaO = 50z$.

Equations are evidently as below:

$$30 + 10y + 10z = 50z \quad (SiO_2 \text{ and CaO equal})$$
$$4(30 + 10y + 10z) = 3(20 + 30y)$$
(Ratio of $SiO_2$ to FeO)

Divide through by 10, etc.:

$3 + y = 4z$ and $6 - 5y = -4z$ are the reduced forms. These give $y = 2.25$ and $z = 1.3125$. Or (multiplying by 100) charge is: Ore No. 1, 100 lb. Ore No. 2, 225 lb. Limestone, 131.25 lb.

*Proof.*

| | $SiO_2$ | FeO | CaO | |
|---|---|---|---|---|
| One No. 1, none. | | | | |
| Ore No. 2, 100 lb | 30 | 20 | ...... | lb. |
| Ore No. 3, 225 lb | 22.5 | 67.5 | ...... | " |
| Limestone, 131.25 lb | 13.125 | .... | 65.625 | " |
| | 65.625 | 87.5 | 65.625 | " |

The figures prove absolutely, i.e., as 3:4:3.

Practically, it is absurd to carry a slag calculation into second decimals of a pound. In demonstrating a *method*, however, it is well to carry accuracy far beyond any actual requirement.

Many changes might be rung on themes similar to these. The cases are not of a class likely to occur in every-day practice, but their discussion shows that there may be a variety of mixes all producing the same slag, and that there is no easier way of treating than the representative equation.

The attempt, in fact, to discuss most of such cases by "excess" would be, while hardly an impossible, certainly a tedious and confusing job.

Very notable is the fact that the equation method becomes *relatively easier* as the problem becomes more complex. Also, the fact that by this method the answer is final at the "first intention," and "readjustment" is never called for, is no small recommendation.

Finally, the proof is readily made, and clinches the figures past all cavil. It is to emphasize the latter point that we have carried out these proofs to an extent that might seem uncalled for.

Denver, Colorado.

---

## Refractometry

BY G. A. SHOOK

### II—Instruments

While a first-class spectrometer may be used for the determination of the refractive index of liquids, if it is provided with a hollow prism, considerable care must be taken in making an observation in order to obtain any degree of accuracy. This fact alone renders it unsuitable for commercial work.

The entire range of refractive indices, in the case of liquids is not greater than from $n_D = 1.3$ to $n_D = 1.7$, so that the spectrometer can be used for all sorts of research work. Where time is of any consideration, however, one of the commercial instruments should be used. Indeed practically all research work is now carried out with one or another of the well known refractometers.

In most all classes of work temperature control is an important factor and, therefore, a refractometer should be provided with suitable means for bringing the liquid, under investigation, up to any desired temperature and for maintaining it there for at least several minutes. Most of the instruments now in use are provided with water-jackets of some sort so that a stream of water may be circulated around the liquid. But the appliances that are provided by instrument makers for regulating the flow of water and for maintaining a constant temperature of the water are not always satisfactory. Of course, if the error introduced by a fluctuation of the temperature is not greater than is permissible, for the particular sort of work under consideration, then most any sort of a temperature regulating device may be used.

The choice of an instrument for measuring indices of refraction depends primarily upon two things: firstly the range of the instrument and secondly its sensitiveness.

Among other things which must then be considered are, the amount of the sample required to make an observation, the ease with which a reading may be made, etc.

Some instruments are provided with a direct-reading scale so that no computation nor even a table is necessary for the determination of $n_D$ while others are provided with arbitrary scales making it necessary to use a table if the index of refraction is desired.

Again white light may be used with some instruments, while with others monochromatic light must be used.

For butter and a number of oils the *Zeiss butyro-refractometer* is almost universally used. It has an arbitrary scale divided into 100 equal divisions and it covers a range of refractive indices from 1.4220 to 1.4895. It has an accuracy of about one unit in the fourth decimal place.

A similar instrument is the *Wollney milk-fat refractometer* which is designed for the determination of fat in milk. Its scale is also arbitrary and its range is from 1.3332 to 1.4220.

The *Abbé refractometer* is provided with a direct-reading scale and its range is from 1.3000 to 1.7000. It is used chiefly for edible fats, oils, lubricants, alkalis, linseed oil, petroleum, milk serum, jams, jellies, etc., etc., and it can be used for any substance whose index of refraction falls within its range. It has an accuracy of about two units in the fourth decimal place.

For dilute aqueous solutions the *Zeiss immersion refractometer* is especially suited. Its scale reads from —5 to 105 corresponding to a range of refractive indices of from 1.32539 to 1.36640 and its accuracy is about four units in the fifth decimal place.

For the determination of the dispersion as well as the refraction the *Pulfrich refractometer* is universally used. While it is more particularly a research instrument, it has been used to estimate alcohol and extract in beer and wine. It has an accuracy of about one unit in the fourth decimal place in the measurement of refraction and about two units in the fifth decimal place in the measurement of dispersion. It is made with the following ranges: 1.33 to 1.61 for liquids, 1.47 to 1.74 for solids and 1.64 to 1.88 for substances of exceptionally high refractive power. Its scale is graduated in circular degrees, but by means of a table the refractive index corresponding to any reading in degrees is readily determined.

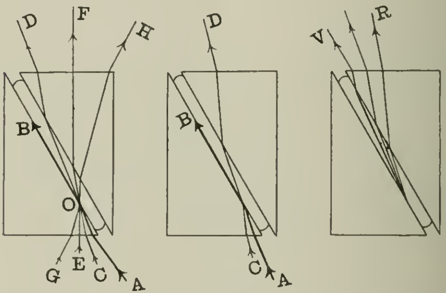


FIG. 1—BUTYRO-REFRACTOMETER DOUBLE PRISM

The Féry instrument has a range of 1.3300 to 1.6700 and is consequently suitable for oils or aqueous solutions. An accuracy of about one unit in the fourth decimal place may be easily obtained. The index of refraction is read directly from a scale attached to the instrument.

The values of the indices of refraction given above are all for sodium light.

The above named refractometers are the ones that are in most common use, although a number of others have been devised.

The theory of some of these instruments will now be taken up in detail.

### The Butyro Refractometer

The essential feature of this refractometer and also that of the Abbé is the so-called double prism. This consists of two similar prisms of highly refracting glass, Fig. 1, which are mounted in hollow cases. A stream of water, at any desired temperature, may be circulated around the prisms in order to maintain them at a constant temperature.

The liquid to be examined is placed between the hypotenuse faces of the prisms. The case containing the lower prism is hinged (at the lower edge) to the case containing the upper one so that it may be swung down to allow the introduction of the liquid.

A few drops only are required since the distance between the two adjoining interfaces is only about 0.015 cm.

The inner face of the lower prism is ground, so that every point upon it is a center from which light diverges. Let us now consider the first prism in Fig. 1.

We will suppose that it is filled with a liquid whose index of refraction is somewhat less than that of the prism. Light from beneath the lower face of the lower prism will pass through the point O in the direction OD, OF or OH, and pass out of the upper prism. But for some particular direction as AO, the light will just graze the surface of the liquid and will not be transmitted.

Any ray making a larger incident angle (with the normal to the liquid surface) than AO will evidently be totally reflected and, therefore, not enter the liquid. If, however, a ray such as COD makes an angle, with the normal, slightly smaller than the critical angle of incidence it will *just* be transmitted, so to speak. We will speak of this particular ray, hereafter, as the *limiting ray.*

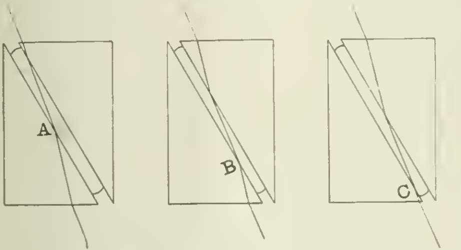


FIG. 2—LIMITING RAYS OF THE DOUBLE PRISM

All of the incident rays to the right of AO will be totally reflected, while all to the left, CO, EO, GO, etc., will be transmitted through the liquid and finally through the upper prism. The same is manifestly true for any point of the ground surface lying on a straight line drawn perpendicular to the plane of the paper through the point O.

Therefore, when one looks at the upper face of the double prism, he sees a light and a dark region separated by a sharp, straight boundary, provided the light is monochromatic.

Now if we consider any other point, along the ground surface of the inner face of the lower prism, such as A, B, or C, Fig. 2, we will have a similar system of rays. That is, parallel to the ray OD, which marks the limit of the light region for the point of divergence O, there will be a ray from the point A, one from B, and one from C, etc.

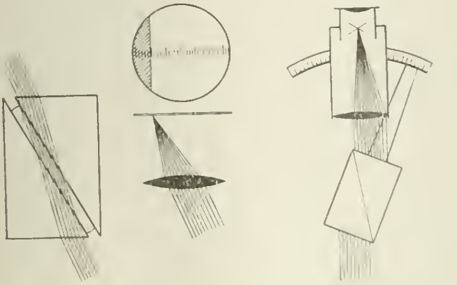


FIG. 3—OPTICAL SYSTEM OF THE BUTYRO REFRACTOMETER

If all of these parallel rays are brought to a focus by means of a lens they will produce an image of the boundary line, Fig. 3.

Moreover, since for every point on the ground surface, the critical angle of incidence must be the same, these limiting rays which just get through the liquid stratum must all be parallel and they must, therefore, all form one image.

The rays which emerge in any other direction, such as OF or OH, will produce by means of the lens images of light centers, as it were, that is to say they will produce a uniformly illuminated area.

In the Butyro-refractometer the upper prism is rigidly fastened to a frame which also supports, directly above the prism, a telescope. The telescope is focused for parallel rays and in the focal plane of its objective is placed a glass disk on which is engraved a scale. On looking through the telescope one sees the field of view divided into a light and a dark region as shown in Fig. 3. The position of the boundary line can be read directly from the superimposed scale.

For a liquid of smaller refractive power than the one just considered, the limiting ray CO will make a smaller incident angle and the emerging ray OD will consequently be more nearly perpendicular, as shown in the second diagram of Fig. 1. The dark portion of the field will in this case extend farther to the right, i.e., the border line will move across the scale.

In the Abbé instrument, instead of a micrometer scale in the telescope, the latter is provided with cross-wires and the double prism is rotated about an horizontal axis until the boundary line coincides with the cross-wires. An index hand or alidade attached to the prism system moves over a scale which is graduated to read the index of refraction, $n_D$, directly.

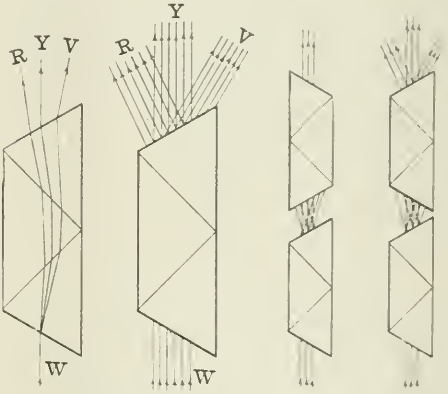


FIG. 4—AMICI PRISMS

Let us now suppose that the limiting ray OD, i.e., the one which produces the image of the boundary line is composed of white light instead of yellow light. As it enters the liquid stratum it will be dispersed into prismatic colors and the rays, corresponding to the various colors, that enter the upper prism, will thus be slightly divergent.

Consequently each ray will give rise to a different image of the boundary line for the position of the image of the boundary line on the engraved scale is determined solely by the direction of the emerging rays. That is, instead of the light and dark region being separated by a sharp colorless line, it will be separated by a colored and somewhat nebulous boundary.

It is readily seen that the upper face of the upper prism might, however, make such an angle with the hypotenuse face that the diverging rays leaving it would all be rendered parallel, in which case there would be but one image of the border line.

For simplicity, let us suppose that we have a violet, a yellow, and a red ray leaving the upper face of the double-prism as illustrated by the third diagram of Fig. 1. Since these three colored rays all make different angles with the prism face each will give rise to a separate image of the border line, but if they were all parallel they would all be brought to the same focus and consequently produce but one image.

Moreover, the direction of these parallel rays might be made the same as that of the yellow ray, in which case the reading of the instrument would be identical with the reading that would be obtained by using sodium light instead of white light or, in other words, the instrument would be "compensated for sodium light."

Evidently a refractometer can not be compensated for all substances. If it is compensated for a liquid of moderate dispersive power then for a liquid of high dispersive power it will not be quite compensated; that is, the rays leaving the upper face of the double prism will not be parallel and, therefore, a colored border line will result. Again it will more than compensate, so to speak, the dispersion of a liquid of low dispersive power.

The Butyro-refractometer prism is so constructed that the border line is achromatised for butter-fat. For a liquid having a dispersion smaller than butter, the red rays are deviated to the right of the yellow rays as shown in the third diagram of Fig. 1 and the violet rays are deviated to the left of the yellow rays, consequently the border line will be red.

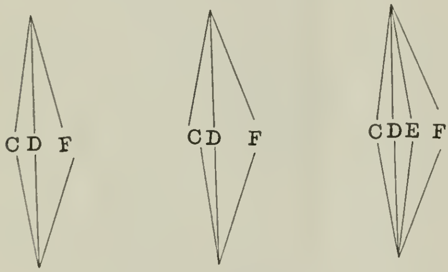


FIG. 5—PARTIAL AND COMPLETE COMPENSATION

For a liquid of greater dispersion the red rays are deviated to the left and the violet to the right of the yellow rays with the result that the border line is blue or violet.

*Therefore a blue border indicates a liquid of greater dispersion than that of butter, while a red border indicates a liquid of less dispersion than butter.*

It may happen, as was pointed out in the first article on refractometry, that two liquids will show the same refraction for, say, sodium light, but quite different mean dispersions and, therefore, the color of the border line should be noted in making an observation with this instrument. With the Abbé, the Zeiss, or the Pulfrich refractometer it is possible to measure the mean dispersion with accuracy, but such a measurement is not always of value.

The range of such an instrument depends manifestly upon the refracting power of the glass used in the construction of its double prism and it cannot, therefore, be altered in any way except by substituting a new prism having a different refracting power.

The only object of the lower prism is to hold the liquid, to be examined, and in one type of refractometer the lower prism is omitted and the upper prism is immersed into the liquid.

### The Abbé Refractometer

The essential difference between the Abbé and the Butyro-refractometer is in the method of compensating for sodium light and in the method of measuring the refraction.

To the double prism of the Abbé instrument is attached an alidade by means of which it may be rotated until the border line coincides with the cross-wires in the telescope, Fig. 3. The alidade moves over a scale on which is engraved the refractive indices.

Since the index of refraction may be read directly from this scale this instrument has some advantage over the one just described. Its chief advantage, however lies in its large range of refractive indices and in its compensating device by means of which the dispersion of practically any liquid may be compensated.

The Abbé compensator consists of two similar amici, or direct-vision, prisms. The amici prism is built of three triangular prisms and the middle prism has a different refractive power from the two outside ones, Fig. 4.

When a ray of white light enters either end of such a prism it is dispersed or spread out as shown. These dispersed rays upon entering the second prism are all bent back toward their original direction, but all to the same extent, i.e., they are not all parallel and, therefore, the dispersion is not entirely destroyed, although it is diminished. When these rays enter the last prism their dispersion is increased and when they enter the air it is further increased, but the general direction of the emerging rays is the same as the incident ray.

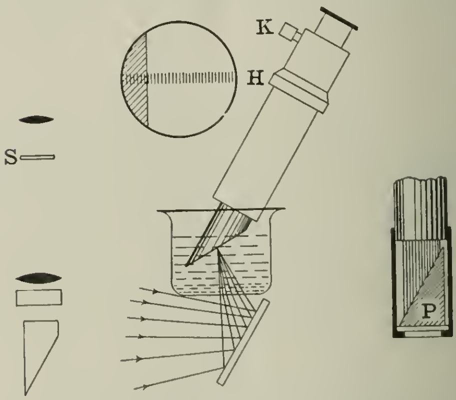


FIG. 6—ZEISS IMMERSION REFRACTOMETER

Evidently the prism can be so constructed that a particular emergency ray (say, the yellow one) will be parallel to the incident ray. Therefore, if a parallel beam of white light is incident on one face of such a direct-vision prism the emerging beam which is parallel to the incident beam will be yellow, while the beams emerging in other directions will have other colors as shown by the second diagram of Fig. 4.

It must be remembered that here we are always dealing with parallel rays of light and, therefore, we are concerned with the direction and not at all with the point, on the face of the prism, at which they emerge. At every point there are emerging rays of all colors and their direction is determined by their color. A diagram giving a more complete picture of such a system of rays would be too complicated to be comprehended.

Let us now consider what happens when parallel rays pass through two such prisms, Fig. 4. If the two prisms are oriented so that they oppose each other, as it were, the dispersion produced by the first will be completely annulled by the second so that a parallel beam passes through them without having its direction changed and without being dispersed.

If, however, they reinforce each other the second prism will augment the dispersion produced by the first. Therefore, by rotating one prism about the common axis of the two it is possible to produce any desired degree of dispersion from zero up to double the dispersion produced by either prism alone.

With respect to the spectrum, the center of rotation, so to speak, is always the D line, but, of course, a prism could be so made that the center of rotation would be any other line.

By means of such an arrangement it is readily seen that the dispersion produced by a liquid, inclosed in the double prism of the refractometer, may be completely annulled. Moreover, the direction of the compensated beam is the same as the direction of the yellow beam so that the reading of the instrument that obtains, when the light is compensated, is identical with the reading that would obtain if yellow light were substituted for white light.

The two amici prisms are mounted in the axis of the telescope between the telescope objective and the double prism and by means of a screw head they may be rotated simultaneously in opposite directions.

The angle through which the prisms must be turned, from the nil position, in order to compensate the dispersion of a given liquid is a measure of its *mean dispersion* and hence by means of the reading of the scale on the drum of the compensator the mean dispersion, $n_F - n_C$, may be computed. Tables are furnished with each instrument to facilitate this computation.

If, therefore, to an observer two oils are given which have the same $n_D$ but different values of $n_F - n_C$ he may distinguish them at once by means of such an instrument.

To be sure, by means of the Butyro-refractometer, one may determine the relative dispersion of oils by the color of the border line, but in such cases the indefiniteness of the border line makes an accurate measurement of the refraction impossible, while with the Abbé the border line may be made sharp and distinct for all dispersions.

It might so happen, of course, that the prisms could be rotated so that the partial dispersion $n_D - n_C$ would be compensated while the remainder of the mean dispersions, namely $n_F - n_D$, would not be compensated as illustrated diagrammatically in Fig. 5.

Again we might be able to compensate the region *F-D*, but not at the same time the region *D-C*, as shown.

In either case a very slight color would be given to the border line, but with most of the liquids with which we have to deal the partial dispersions are proportional to the mean dispersions so that if the mean dispersion of the compensator is made equal to the mean dispersion of the liquid the partial dispersions throughout the spectrum will be practically compensated as illustrated in the third diagram of Fig. 5.

### The Zeiss Immersion Refractometer

This instrument is not essentially different from the two just described.

The lower half of the double prism is omitted and the upper half is mounted in the end of a tube which contains a compensator and a telescope, Fig. 6. This tube is either hung on a rack or simply held in the hand. To make an observation it is only necessary to immerse the prism into the liquid whose index of refraction is desired.

The liquids to be examined are placed in small beakers and the latter are arranged in a water bath. This is simply a shallow metal tank provided with a glass bottom and an illuminating mirror so arranged that diffused sunlight may be reflected through the bottom of each beaker. The refractometer may then be dipped into one beaker after another.

In order to keep the beakers at a constant temperature the bath is filled with water at any desired temperature and the beakers are allowed to stand in it about ten minutes before any observations are made or the water is allowed to flow slowly through the tank.

The temperature of the bath is generally indicated by an ordinary thermometer immersed in the water, but in order to be sure that the solutions in the beakers have the same temperature as the surrounding water, it is necessary from time to time to measure the temperature of one or more of the solutions.

Whenever it is possible to provide a large quantity of the material to be tested, this instrument may be used efficiently as a large number of samples can be examined in a comparatively short time.

Its use is, however, limited to aqueous solutions or liquids having an index of refraction of about the magnitude of water.

The method of controlling the temperature of the substances to be tested is not the most satisfactory, however, since it is practically impossible to maintain a constant uniform temperature throughout such a large bath.

When only a small quantity of the sample can be obtained an auxiliary prism *P* is used. It is mounted in a short tube which can be secured to the refractometer tube, thus making a double prism. This arrangement is also used for volatile liquids.

There is a decided advantage, however, in using the single prism, for the border line is sharper than it is when the lower prism is used. Due to the fact that the border line is sharper a higher magnification may be used and consequently greater accuracy is possible.

The border line is made colorless by turning the collar *H* which in turn actuates the compensator. A fine adjustment is attached to the enclosed scale *S* and by means of a drum *K* the tenth part of a scale division may be easily read.

The ease with which this instrument can be manipulated and its extreme sensitiveness renders it invaluable for the investigation of solutions.

### The Pulfrich Refractometer

This instrument has no compensating device and, therefore, white light cannot be used.

It is provided with a Geissler hydrogen tube and sodium light is also used, so that the refractive index may be determined for the C, D, F, or G′ line and the dispersion may be determined for the interval D-C, F-D, G′-F, etc.

Light from a sodium flame, or any other source of monochromatic light, is rendered slightly convergent by means of a lens and thence passes into a right-angled prism under grazing incidence, Fig. 7.

The liquid to be tested is held in a short glass cylinder which is cemented to the top face of the prism.

Let us imagine that the three glass tubes in Fig. 7 are all filled with the same liquid and that, moreover, no light can pass into the prism except through the top face.

Since the index of refraction of the glass prism is much greater than that of the liquid to be tested, any ray, *AB*, passing along the interface will be bent into the glass at some point, *B*, and will pass out into the air along the path *BCD*.

For some other point, *F*, a ray entering the cell at grazing incidence will take the path *EFGH* and another ray the path *JKLM*, etc.

Therefore from the vertical face of the prism there will emerge a beam of parallel rays which have their origin from the rays that enter the top face of the prism under grazing incidence.

Any ray such as *PQ*, Fig. 8, which makes a small angle with the prism surface will, of course, pass into the prism and out again along some such paths as *QRS*. This emerging ray *RS* evidently makes a larger angle with the normal than the ray *CD*, which is due to the light entering the prism under grazing incidence.

Manifestly no light whatever will be transmitted in the direction *UV*, since *UV* makes a smaller angle with the normal than the ray *CD* and would consequently have to arise from a ray having the direction *TQ*, but no light can pass along the path *TQ*, since none enters the prism except through the top face.

Therefore, if an observer were to examine the vertical face of the prism by means of a telescope, focused for parallel rays, he would observe that the field of view were divided into a light and a dark region by a sharp boundary line as shown in Fig. 8.

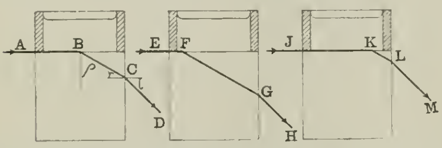


FIG. 7—TOTALLY REFLECTING PRISM OF THE PULFRICH REFRACTOMETER

The angle *i*, Fig. 7, depends clearly upon the refractive index of the glass and of the liquid. For a given glass prism, therefore, *i* will depend solely upon the refractive index of the liquid contained in the glass tube.

Now suppose that the light were passing in the direction *DC*, then if the index (referred to air) for glass is *N* it follows at once that

$$N = \frac{\sin i}{\sin r}$$

Moreover, the index of the liquid (referred to air) is

$$n = \frac{\sin \varphi}{\sin 90} \times N = \sin (90 - r) \times N$$

$$= \cos r \times N = \sqrt{N^2 - N^2 \sin^2 r}$$

But

$$\sin^2 r = \frac{\sin^2 i}{N^2}$$

hence

$$n = \sqrt{N^2 - \sin^2 i}$$

Knowing the index for the glass, *N*, the index of any liquid, *n*, may be readily computed if the angle *i* is known. Tables are furnished with each instrument so that the index of refraction, *n*, may be readily obtained from the value of *i* (in degrees).

In reality the telescope is at right angles to the emerging beam and the beam is reflected into it by means of a 45 deg. prism. The telescope is attached to an arm which rotates about an horizontal axis which lies in the plane of the vertical face of the prism. This arm is provided with an index which moves over a scale so that *i* may be read in degrees. To make an observation it is only necessary to rotate the arm, carrying the telescope, until the cross-wires of the latter coincide with the boundary line between the bright and dark region.

The scale is also provided with a micrometer attachment so that small differences in *i* can be readily measured to within one-tenth of a second. Very often one is concerned only with small differences in the refractive index, such as may be caused by small changes in temperature, in which case the micrometer is extremely convenient.

When it is desired to measure the difference in the refractive powers of two liquids, for example, water and a weak solution of alcohol, a special form of cell is sometimes used. It is provided with a black glass partition and when the cell is in position the partition is perpendicular to both prism faces.

The two liquids to be examined are placed in the two separate compartments. Two border lines will now be observed instead of one and the angular difference between them can be easily and accurately measured by means of the micrometer. All errors due to temperature differences are thus avoided.

The temperature of the liquid is controlled by means of a hollow casing surrounding three sides of the prism, through which a stream of water at any desired temperature or steam may be passed. The liquid may also be heated inside the glass cylinder directly by means of a cylindrical heating vessel, of special construction, which dips into the liquid, *W*, Fig. 8.

The water or steam from the casing of the prism passes through the heating vessel and comes in direct contact with the bottom plate of the same. The vessel can be lowered until it is less than a millimeter from the prism surface so that there is practically no uncertainty whatever as to the temperature of the liquid.

### The Féry Refractometer

This instrument has several decided advantages over those just described. The index of refraction of any transparent liquid may be read directly with an accuracy of about one unit in the fourth decimal place and the scale extends with uniform accuracy from 1.3300 to 1.6700. Sodium light is used so that no compensating device is necessary. No auxiliary heating apparatus is required, since the temperature control is an integral part of the apparatus. Moreover, it is only necessary to have 1 cc to 2 cc of the liquid to be tested.

A diagrammatic view of this refractometer is shown in Fig. 9. The essential parts of the apparatus are: a collimator, *C*, of special construction; a telescope, *T* (in line with the collimator); a double cell, *S*, and a heating device not shown.

The outer cell is entirely of metal with the exception of the two larger sides which are plano-convex lenses as shown. The inner widge-shaped cell is made of glass and into this cell the liquid to be examined is introduced. The space between the inner and outer cell is filled with water which may be heated to any desired temperature by means of a thermo-syphon which is actuated by a small lamp attached to the double cell. A copper tube of small diameter is brazed to the metal chimney of the lamp and the two ends of this tube are inserted into one end of the outer cell so that an active circulation of the water is produced.

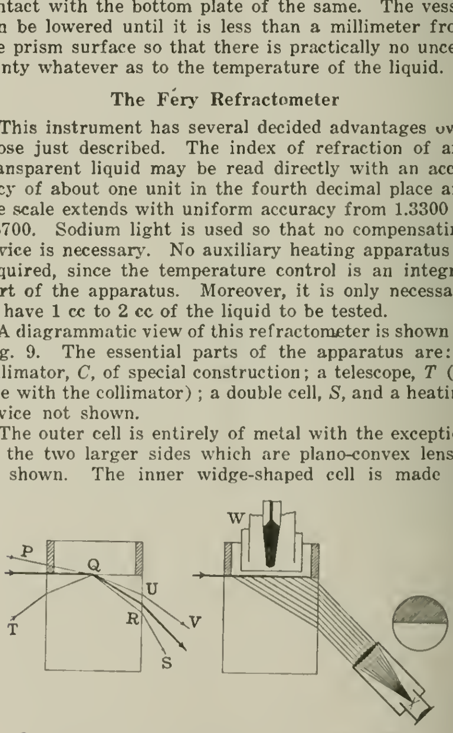


FIG. 8—OPTICAL SYSTEM OF THE PULFRICH REFRACTOMETER

By means of a rack and pinion the double cell may be moved perpendicular to the optical axis of the instrument. When the telescope is properly adjusted, the image of a fine wire in the focus of the collimating lens coincides with the cross-wires of the telescope.

Now when the cell is symmetrical with respect to the axis of the collimator and telescope, the prism of liquid deflects the beam from the collimator out of its path so that the wire image no longer coincidees with the cross-wires of the telescope.

By moving the double cell, however, the wire image can be made to coincide with the telescope cross-wires and the movement necessary to effect this condition is a measure of the index of the liquid under consideration.

The action of this double cell may be readily understood by means of Fig. 10. If the inner cell were not present then the beam from the collimator would pass directly through the two lenses as shown by the first diagram. If now a wedge of any transparent substance, for instance, glass, were placed in the cell, the beam would be deflected and would not pass directly through the telescope as shown by the second diagram. The beam can, however, be brought back to its original direction by moving the cell to one side as shown by the third diagram.

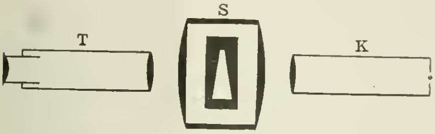


FIG. 9—FÉRY REFRACTOMETER

For a prism set at minimum deviation, the index of refraction, in terms of the prism angle, $A$, and the deviation angle, $D$, is given by the well-known formula

$$n = \frac{\sin\left(\frac{A+D}{2}\right)}{\sin\frac{A}{2}}$$

In this case $A$ and $B$ are both small so that the sign is practically equal to the angle when the latter is measured in radians.

Therefore,

$$n = \frac{A+D}{A}$$

or

$$D = A\ (n - 1)$$

That is, the index, $n$, is directly proportional to the deviation $D$. The lenses of the outer cell constitute prisms of variable angle.

At the pole of the lens this angle is evidently zero, but at the periphery it has a small but finite value. Moreover, this angle varies directly with the distance from the pole of the lens. A little consideration will show that the deviation, $D$, is directly proportional to the distance that cell must be moved in order to compensate for the deviation produced by the liquid prism.

The divisions of the scale, which is attached to the double cell, are therefore equal; moreover, each division represents the same increment in $n$. By moving the inner cell (in the direction of its length) with respect to the outer cell the direction of the emergent beam is manifestly altered and consequently the range of the instrument is changed. It is by this simple expedient that the range of the instrument is increased without diminishing its accuracy.

For one position of the inner cell it reads from 1.3300 to 1.5326, and this range is suitable for most of the liquids of industrial interest. By shifting the cell to another position the range of the scale is extended by 0.14 so that it works between 1.4700 and 1.6726.

It is thus seen that the type of instrument which is best suited to a particular laboratory depends entirely upon the class of substances to be analyzed and upon the conditions under which the analysis is to be carried out.

* * *

If the samples to be tested differ widely in their refractive powers then unless more than one instrument can be purchased the choice lies between the Abbé and the Féry refractometers.

If, furthermore, only a drop or two of the sample can be obtained, which is seldom the case, the Abbé instrument would be more applicable than the Féry.

The Féry instrument, however, is more accurate and more self-contained since its heating control forms part of the apparatus. For the exclusive examination of solutions the Zeiss instrument is preferable, provided a comparatively large quantity of the sample is available.

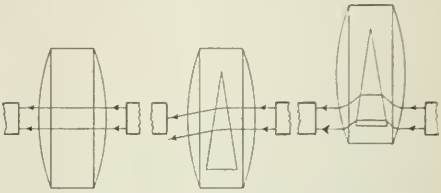


FIG. 10—DOUBLE BELL OF THE FÉRY REFRACTOMETER

If it is desired to measure the dispersion as well as the refraction, then either the Abbé, the Zeiss or the Pulfrich instrument may be used.

The Pulfrich is undoubtedly more accurate for dispersive measurements than the Abbé or Zeiss, but, on the other hand, a measurement of the dispersion is more easily made by means of either of these two instruments.

For research work the Pulfrich refractometer is probably the best all-round instrument.

University of Michigan,
Ann Arbor, Michigan.

---

**Direct shipments** of freight into Mexico over the International bridge between Nuevo Laredo, Mexico, and Laredo, Texas, have been resumed.

**The domestic iron-ore output in 1913** was the largest in the history of the country, according to figures issued by the Geological Survey, amounting to 61,980,437 long tones, an increase of over six million tons over the production of 1912. Minnesota produced over five-eighths of the total. The Mesabi range produced nearly 70 per cent of the entire Lake Superior output, and nearly 59 per cent of the production of the country.

**Stratton's Independence, Ltd.**, at Cripple Creek, produced 1176 tons of mine ore averaging about $16 per ton, and the mill treated 11,700 tons of low-grade mine and dump ore, during the month of June. The net working profit to the company from both mine and mill operations was $14,420.

**The potentials of different minerals** when employed as electrodes in different solutions is one of the subjects discussed in *Bulletin* 548 of the U. S. Geological Survey, entitled Electric Activity in Ore Deposits. Although the object of the investigation is primarily related to mining and geology, some of the experimental work is of interest to electrometallurgists. The electric conductivity of minerals, measurements of potential assumed by certain minerals, and electromotive behavior of soluble sulphides are some of the subjects discussed.

# Cyanide Practice in the Porcupine District, Ontario, Canada—II

BY H. C. PARMELEE

In a previous article[1] reference was made to the fact that, of the four principal cyanide mills in the Porcupine district, no two have adopted exactly the same method of ore treatment, and that in spite of the general similarity of the ores there is marked diversity in the methods. In order to bring this point clearly to mind, a comparison has been made in Table I, showing the different steps and means of accomplishing them.

TABLE I—COMPARISON OF METHODS OF PROCEDURE ADOPTED AT PORCUPINE CYANIDE MILLS

| Mill | Crushing | In | Classifiers | Amalgamation | Concentration | Cyanidation | Filtration | Precipitation | Refining |
|---|---|---|---|---|---|---|---|---|---|
| Hollinger...... | Stamps and tube mills | Solution | Dorr | None | Deisters | Continuous decantation of slime. Agitation of concentrate | Moore vacuum | Zinc dust | Blast furnace Cupellation |
| Porcupine-Crown .... | Stamps and tube mills | Solution | Dorr | Following tube mills | None | All-sliming. Continuous decantation | None | Zinc dust | Rockwell furnace |
| McIntyre... | Rolls, Hardinge ball mills and tube mill | Solution | Dorr | None | None | All-sliming. Continuous decantation | None | Zinc dust | Crucible furnace |
| Dome........ | Stamps and tube mills | Water | Colbath | Following tube mills | None | Leaching of sand. Agitation of slime | Merrill press | Zinc dust | Blast furnace. Cupellation |

### Continuous Decantation at the Porcupine Crown Mill

One of the most interesting mills in the district is that of the Porcupine Crown Mines, Ltd., at Timmins. The principal feature of the plant, and the one that lends simplicity to the metallurgical scheme, is continuous counter-current decantation for the displacement and recovery of valuable solution from the impoverished ore-slime. The diagram in Fig. 1 gives an outline of the treatment, and shows also the more important data relative to continuous decantation.

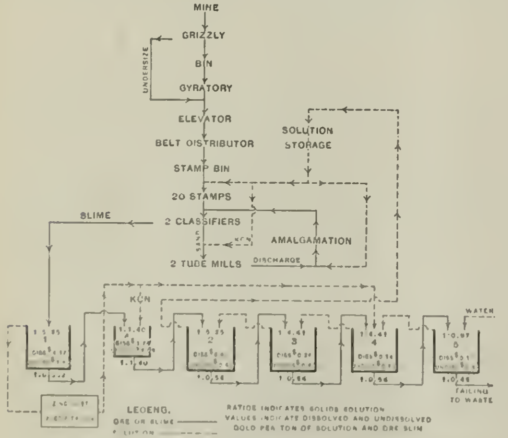


FIG. 1—DIAGRAM OF ORE TREATMENT AT PORCUPINE CROWN MILL

The ore is mainly quartz containing free gold. There is less schist than at some of the other properties, and only 1 per cent of pyrite, as compared with from 5 to 10 per cent elsewhere in the district. The value of the mill feed ranges from $15 to $30 per ton. Some of the gold is coarse and readily amalgamable; the balance is easily soluble in a comparatively weak cyanide solution. The ground ore is granular and settles rapidly, so that on the whole the metallurgical problem is simple and the process well adapted to the requirements and conditions.

There is nothing particularly new in the preparation of the ore for cyaniding. It is screened through a grizzly, 1½-in. spaces, and the oversize is crushed in a gyratory and combined with the grizzly undersize. The whole is then elevated and distributed to the stamp bins. Challenge feeders deliver the ore to twenty 1050-lb. stamps, arranged in batteries of ten each, with separate cam shafts for each group of five. A 40-hp. motor with silent-chain drive serves each battery.

### Crushing and Grinding in Solution

The ore is stamped in mill solution returned from the continuous decantation system, four tons of solution being used per ton of ore. The stamp discharge flows to Dorr classifiers which deliver the coarse portion to tube mills for regrinding. The tube mill product is elevated to amalgamating plates and returned to the classifiers. Thus tube milling and amalgamation are performed in a closed circuit, and there is no opportunity for escape of the pulp until coarse gold has been amalgamated or ground fine enough to escape with the slime.

El Oro lining is used in the tube mills, but the Globe liner, previously mentioned in the description of the Hollinger mill,[2] is to be given a trial. The pebble load is maintained at 0.6 the volume of the tubes. The mill solution used in the tube mills is first strengthened with cyanide, and the flow regulated to give 38 per cent moisture in the pulp. The latter is then suitably diluted with mill solution before amalgamation. Preliminary experiments in grinding for cyanidation showed that the critical degree of fineness for this ore was about 150-mesh. In current mill practice 88 to 90 per cent of the ore is finer than 150-mesh and 75 per cent finer than 200-mesh.

The well known difficulty of maintaining amalgamating plates in good condition when using cyanide solution is experienced at this mill, but the plates serve their purpose of catching coarse gold, and effect about one-third of the total recovery. The amalgam is hard and must be scraped from the plates, care being taken not to cut too deep and injure the amalgamating surface.

### Continuous Counter-Current Decantation

The overflow of the classifiers, consisting of 1 part of solids and 5.25 parts solution, passes to the continuous decantation plant which comprises five Dorr thickeners, 30 ft. by 12 ft., and two Dorr agitators, 16 ft. by 16 ft., together with the necessary complement of diaphragm pumps for transfer of pulp. This machinery is housed in the long structure shown at the left in Fig. 2, the crushing, grinding and amalgamating equipment being placed in the higher part at the right. An interior view of the continuous decantation plant is given in Fig. 3, looking from left to right through the building shown in Fig. 2. The relation of the thickeners and agitators is shown diagrammatically in Fig. 1, and the counter-current flow of solids and solution, and displacement of the latter will be readily understood by reference thereto. There is no filter in this plant.

---

[1] This Journal, September, 1914, p. 567.

[2] Ibid.

Examination of the figures given in the flow sheet will show uniform reduction in value of the solution throughout the line of thickeners, ending with a value of only ten cents per ton in No. 5. As the discharge from this thickener contains only 0.43 ton of solution per ton of ore, the loss of dissolved gold is but 4.3 cents per ton of ore, which is a remarkably satisfactory result and one that compares favorably with displacement by filtration. Recyaniding tests on the washed tailing show that only an inconsiderable quantity of gold can be extracted without finer grinding. The only water entering the system is used to dilute and wash the pulp in No. 5 thickener and counterbalance the loss of solution in the tailing.

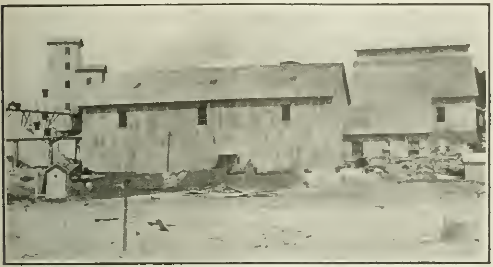


FIG. 2—PORCUPINE CROWN MILL

The physical arrangement of the thickeners is such that overflowing solutions pass by gravity from No. 5 to No. 2. A suggestion of the arrangement can be gathered from Fig. 3, wherein the upper part of thickener No. 5 is seen in the central background, and No. 4 at a lower level in the left center. No. 3, not visible, is at a still lower level in line with Nos. 5 and 4. The rim of No. 2 is barely seen in the right foreground, with a launder leading to it from the agitator which is in the right center. Thickener No. 1 is behind the agitator. Fig. 4 shows the manner of supporting the thickeners on concrete piers, providing for the proper elevation of the vats and permitting ready access to the discharge pipes.

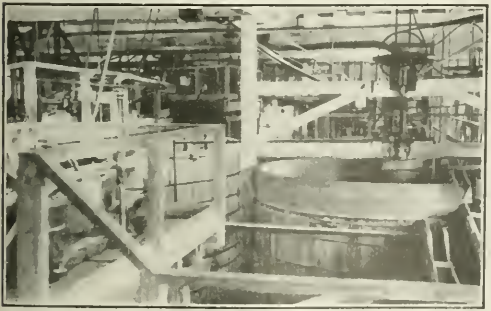


FIG. 3—CONTINUOUS DECANTATION PLANT, PORCUPINE CROWN MILL

**Thickened Pulp Transferred by Diaphragm Pumps**

Diaphragm pumps are used for the transfer of thick pulp throughout the system. These are installed in duplicate at each point of transfer, one being held in reserve. They are ordinary contractor's pumps, costing about $35 each. As originally purchased they are operated by cranks, but give better satisfaction when driven from eccentrics. The change is easily made and results in less lost motion and longer life of diaphragms. As installed at this mill the pumps have two speeds and three lengths of stroke whereby the volume of pulp handled can be varied to suit conditions in the thickeners and possible changes in mill tonnage.

In the design of the continuous decantation plant, four square feet of settling area was provided per ton of dry slime, based on the treatment of 180 tons per day. Only one agitator was originally installed, but a second has been added, as it was found that dissolution of gold continued through the line of thickeners, indicating insufficient agitation. Although but one agitator is shown in the diagram, there are two connected in series. One-third of the cyanide is added to the barren solution that dilutes the pulp in the agitators, the balance being added at the tube mills. Lime is mixed with barren solution in a small barrel, and the resulting emulsion can be conducted through launders to all thickeners and agitators, so that alkalinity can be maintained as desired.

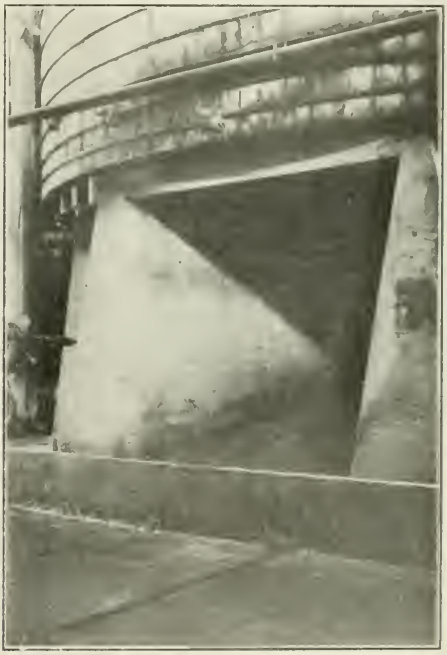


FIG. 4—CONCRETE FOUNDATION FOR THICKENERS

The ratios and values given in Fig. 1 represent conditions in the month of April, 1914. The strength of solution is 1.25 lb. KCN per ton; protective alkalinity is 1 lb. per ton. Chemical consumption per ton of ore milled is 0.75 lb. KCN and 3.5 lb. CaO. Zinc dust consumption is $^1/_6$ lb. per ton of solution precipitated. About four tons of solution is precipitated per ton of ore treated. Value of the head solution in April was

$2.32; tailing solution, $0.03. Percentage recovery is between 96 and 97, and milling costs range from $1.20 to $1.25, exclusive of charges for administration, depreciation, etc.

### Precipitation and Refining

The overflow from thickener No. 1 is the solution precipitated. This solution is first clarified through gravity filter leaves and then pumped to a Merrill press by an Aldrich triplex pump, at the suction of which zinc dust emulsion is introduced. A clean-up is made twice monthly. The precipitate is treated with acid, pumped to a Perrin press and washed therein. The press cake is then partly dried and mixed with fluxes in the following quantities per 100 lb. of precipitate: borax glass, 11.5 lb.; soda, 5.7 lb.; silica, 3 lb. This mixture is then briqueted, dried and melted in an oil-fired Rockwell furnace, yielding bullion about 850 total fineness, of which 90 to 100 is silver and the balance gold.

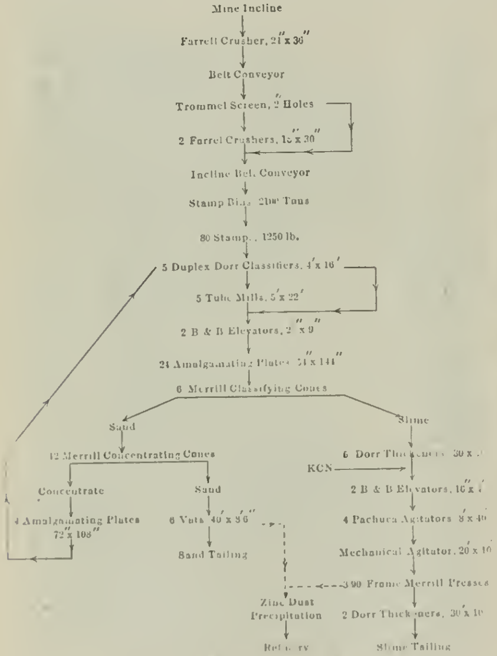

Mine Incline
Farrell Crusher, 24" x 36"
Belt Conveyor
Trommel Screen, 2" Holes
2 Farrel Crushers, 15" x 30"
Incline Belt Conveyor
Stamp Bins 2000 Tons
80 Stamps, 1250 lb.
5 Duplex Dorr Classifiers, 4' x 16'
5 Tube Mills, 5' x 22'
2 B & B Elevators, 2" x 9"
24 Amalgamating Plates 54" x 144"
6 Merrill Classifying Cones
Sand
Slime
12 Merrill Concentrating Cones
6 Dorr Thickeners 30' x
KCN
Concentrate
Sand
2 B & B Elevators, 16" x
4 Amalgamating Plates 72" x 108"
6 Vats 40' x 8' 6"
4 Pachuca Agitators 8' x 40'
Sand Tailing
Mechanical Agitator, 20' x 10'
3 90 Frame Merrill Presses
Zinc Dust Precipitation
2 Dorr Thickeners, 30' x 10'
Refinery
Slime Tailing

FIG. 5—ORE-TREATMENT DIAGRAM, DOME MILL

All of the floors in this mill are of cement, draining to a concrete sump at the foot of the mill. A hint of this construction is given in Fig. 4, showing the floor beneath the thickeners. This is a commendable feature in mill construction that contributes to cleanliness and prevents loss of valuable solution through accidental overflows from any of the machines. A centrifugal pump placed in the sump returns the accumulation to the tubemill-classifier circuit.

### The Dome Mill

Radical changes have recently been made at the mill of the Dome Mines Co., Ltd., at South Porcupine. Not only has the capacity of the mill been doubled and the mechanical method of preparing and handling the ore been changed, but the metallurgical scheme also has been altered by the abandonment of primary amalgamation following the stamps, and the introduction of sand-slime separation, with leaching of the sand product. The slime is cyanided by agitation and filter-pressing as heretofore. The equipment and new scheme of treatment are shown diagrammatically in Fig. 5. Some data on former mill operation have been published in this journal.[3]

In explanation of the changes that have been made, it may be said that they have been due in large measure to the way in which the mine has developed. When the original mill was designed the mine had not been opened extensively and the ore was high-grade. Furthermore, there was urgent demand for a mill on the part of the company, and the plant had to be designed on rather meager data regarding future ore supply. With the development of the mine, larger bodies of low-grade ore were disclosed,[4] and the problem became one of handling a large tonnage of low-grade ore most economically. Tests made in the interim yielded information that could not have been gained originally, and suggested the changes in practice that have since been made. The remodeled mill will handle double the tonnage of the former, and an effort will be made to treat about 1000 tons of ore daily. There will be little more cost for labor, and grinding cost will be reduced as half the ore will be leached instead of being finely ground and agitated. The general effect of the change, therefore, is to increase tonnage and reduce operating cost.

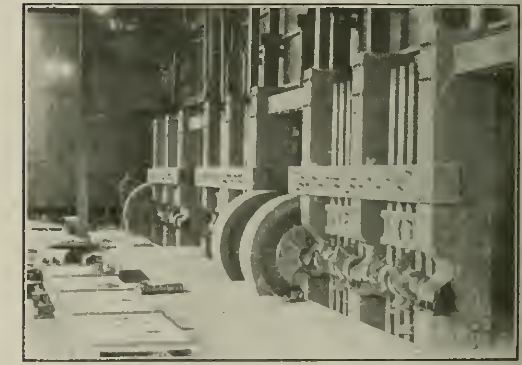


FIG. 6—NEW STAMPS, DOME MILL

### Jaw-Breakers Supersede Gyratories

For coarse breaking gyratories have been displaced by Farrell jaw crushers with water-cooled bearings. The objection to the gyratories was the high cost of repairs due to excessive wear in the bottom bearings. It appears that fine schist dust gradually worked its way into these bearings and gave considerable trouble.

The crushed ore is elevated by an inclined belt-conveyor to the mill bins, above which provision has been made for screening out the fine portion and by-passing it to the tube mills, thus relieving the stamps of an unnecessary burden.

The new addition of forty stamps has been placed back-to-back with the original forty. A view of part of the new installation is shown in Fig. 6. The battery foundations are of concrete, recessed along the sides to receive 8 in. by 8 in. timbers through which the 1½-in. mortar bolts pass. Both mortar and post bolts are removable without difficulty. The mortars are fitted with manganese-steel liners, and the shoes and dies are of forged chrome steel.

---

[3] The Dome Mill, D. L. H. Forbes, this journal, May, 1914, p. 349

[4] In the company's annual report for 1913 it is stated that development work has disclosed a large tonnage of ore assaying from $3.50 to $5 per ton.

### Ore Crushed in Water and Amalgamated

The Dome is the only one of the large Porcupine mills to adopt crushing in water. It is also the only one in which amalgamation is relied upon for the major part of the recovery, amounting in this instance to from 60 to 70 per cent. Of this quantity, about 90 per cent is recovered on the tube mill plates and 10 per cent on the plates following hydraulic classification.

With the adoption of coarse crushing in the batteries, the practice of amalgamating the stamp discharge has been discontinued. Stamp duty has increased from 6½ tons per 24 hours with 18-mesh screen to 14 tons with ton-cap screen of about ½-in. aperture. The battery discharge flows to Dorr classifiers which deliver the coarse portion to tube mills. Formerly, when all-sliming was practiced, the tube mill discharge was returned to the classifier, and only the slimy overflow of the latter was considered a finished product of the grinding department. Now the tube mill discharge is combined with the classifier overflow and much less fine grinding is done than formerly. From 40 to 50 per cent of the pulp is finer than 200-mesh; all will pass 60-mesh.

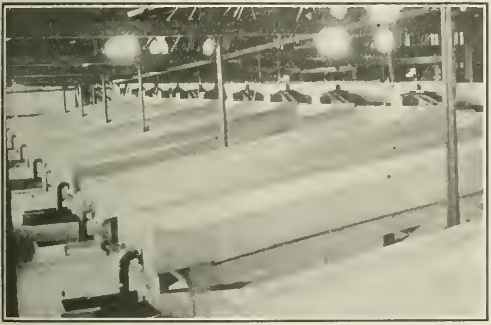


FIG. 7—AMALGAMATING PLATES, DOME MILL

The El Oro lining has been adopted in these tube mills. Silex linings have been tried and found less satisfactory. The former last about nine months as against seven months for the latter. Pebble consumption is 4½ lb. per ton of ore ground.

Twenty-four amalgamating plates, 54 in. by 144 in., are placed on the upper floor of the new addition to the mill, being arranged in two rows of twelve each on either side of a central launder. Fig. 7 gives a view of part of the plates and shows the pulp-distributing system.

### Hydraulic Classification of Sand and Slime

From the plates the pulp flows to a series of Merrill hydraulic cones where a separation of sand and slime is made, approximately in equal parts. The sandy portion is then treated in Merrill concentrating cones, where the pyritic concentrate, that constitutes from 5 to 8 per cent of the ore, is separated. This is first amalgamated and then returned to the classifiers and tube mills. By this method of handling the concentrate, it is not separated for special treatment as at the Hollinger, but reground until it is fine enough to escape from the classifiers with the slime.

The sand separated from the concentrating cones flows through Butters and Mein distributers to leaching vats on the floor below the plates. A view of the vat room is given in Fig. 8. These vats are 40 ft. by 8½ ft., with the usual filter-bottom. The surface of the bottom slopes from two opposite sides of the vat to a median line, at each end of which is a gate for discharge of the leached sand. A complete cycle of filling, leaching, washing and discharging requires about 6 days time, of which 5 days is required for leaching. The ore column is 7½ ft. high and the leaching rate is 2½ to 3 inches.

### Slime Agitated and Filter-Pressed

Slime from the hydraulic cones is first thickened in Dorr continuous thickeners. Cyanide is added and the pulp is agitated for fourteen hours in four 8-ft. by 40-ft. Pachuca tanks connected in series. Air is used at 20 lb. pressure. The agitated pulp is collected in a storage tank where it is mechanically agitated to prevent settlement, and from which charges are drawn intermittently for filtration through Merrill presses. In view of the well-known adaptability of the Merrill press to the leaching of granular slime *in situ*, it is possible that the Pachuca agitators might be cut out and the slime dewatered and leached in the presses.

Pregnant solution from the presses and the leaching vats is precipitated with zinc dust in the usual manner. Consumption of zinc dust is one-fifth to one-sixth of a pound per ton of solution. The refining process is similar to that used at the Hollinger, except that the precipitate is given an acid treatment before it is fluxed and smelted. The resulting base bullion is cupelled. Amalgam is retorted and refined in the usual manner. The final bullion is about 990 fine, of which 100 is silver.

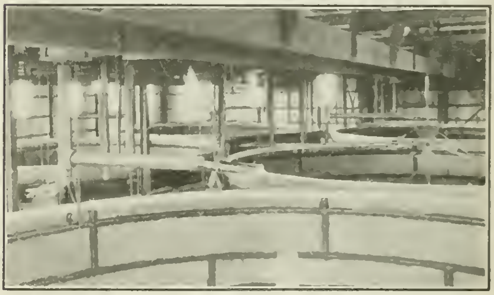


FIG. 8—LEACHING VATS, DOME MILL

The new scheme of treatment has not been in effect long enough to secure average data on operation. In 1913, under the old process of all-sliming, the average value of the ore treated was $8.77 per ton; recovery 94.51 per cent; percentage of total recovery by amalgamation, 60.7, and by cyanidation, 39.3. Average cost of milling was $1.44 per ton, distributed as follows: stamping, tube milling and amalgamation, $0.86; thickening, cyaniding and precipitating, $0.50; refining, $0.08. Coarse breaking and conveying to the mill cost $0.25 per ton, but this item is expected to be materially reduced under the new scheme.

### The McIntyre Mill

Important changes and increase of capacity have been contemplated at the 150-ton mill of the McIntyre-Porcupine Mines, Ltd., at Schumacher. Filtration in a Burt revolving filter is to be superseded by continuous decantation. Consequently little will be said about current operations as they are likely to be changed materially. There are, however, a number of interesting features about this plant that merit consideration.

The ore treated at the McIntyre differs from that at the other mills in the quantity of schist contained. At times this material constitutes as much as three-fourths of the mill feed. Pyrite exists in varying quantities, from 5 per cent to 10 per cent. Some of the pyrite is nearly barren, but much of it carries gold which is readily soluble when finely ground. In fact, when the mill is running on the more heavily mineralized ore, 80 per cent of the total gold extraction takes place in the tube mill-classifier circuit. This action is not so marked when treating ore that is mainly quartz, and subsequent agitation then becomes of greater importance. No trouble is experienced from foul solutions, and aside from being slightly acid, the ore contains no cyanicides.

### Rolls and Hardinge Ball-Mills for Grinding

The first distinguishing feature of McIntyre practice is the use of rolls and Hardinge ball-mills for the intermediate crushing performed at the other plants by stamps. A tube mill in closed circuit with a classifier completes the fine-grinding system. This combination of crushing and grinding apparatus offers some advantages in simplicity, both in installation and operation, as compared with stamps. The cost for supplies at the McIntyre amounts to only 7 cents per ton for steel consumed in the Hardinge ball-mills, including balls and the metal discarded in worn liners. Crusher and roll supplies cost 1 cent per ton. In addition to the simplicity of the roll-ball mill combination, there is also a certain advantage in the absence of noise which characterizes a stamp mill. It has been observed before that "noise costs money" in a variety of ways, and that, other things being equal, the quiet machine is preferable to the noisy one.

Coarse breaking at the McIntyre is performed with crushers of the Blake type, set to deliver a 1-in. product. Rolls reduce this to ¼ in., at which size the ore is fed to the Hardinge ball mill and ground in mill solution. Carborundum blocks are successfully used to prevent corrugation of the roll shells, which, after having been in service for fifteen months, had an estimated further life of eight to ten months.

### Tube Milling in Closed Circuit

The ball mill feed is equal parts of ore and solution. Balls vary in size from 5 in. to 3 in. in diameter, and both liners and balls are of chrome steel. The following table gives a screen analysis of the average discharge of the ball mill, grinding 150 tons per day and consuming 33 hp.

| Mesh | Per cent |
|---|---|
| + 20 | 5.0 |
| + 40 | 22.6 |
| + 60 | 9.6 |
| + 100 | 15.0 |
| + 200 | 13.4 |
| − 200 | 34.4 |

This product goes to a Colbath screw classifier, where it is diluted with mill solution in the ratio of 3 or 3½ to 1. The slime overflows to Dorr thickeners, the balance going to a tube mill and returning to the classifier. Little dissolution of gold takes place in the Hardinge mill, where approximately 40 per cent of slime is made, and subsequent agitation must be relied upon to extract the gold from this portion of the ore. Approximately 60 per cent, however, gets repeated agitation in the classifier and tube mill, where the major part of the metal is dissolved. Cyanide is added at the tube mill, where the consumption is heaviest. The tube mill pulp contains 35 per cent moisture.

### Continuous Decantation of Slime

The overflow from the classifier contains 3 per cent to 4 per cent solids coarser than 100-mesh, and 10 per cent to 12 per cent coarser than 200-mesh. The balance is finer than 200. The plus 100-mesh portion is almost barren and consists of flaky schist that is difficult to grind. Formerly the slime was treated by continuous decantation in two steps with intermediate agitation, and the pulp was finally filtered in a Burt revolving filter. The overflow of the primary thickener was precipitated, and the solution from the filter was returned as mill solution.

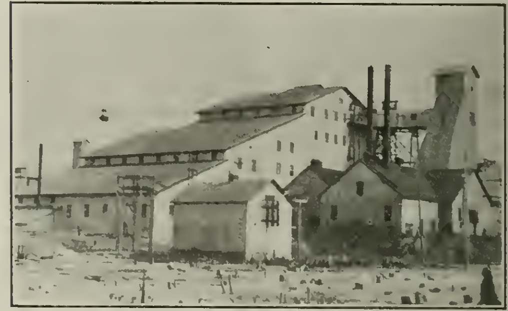


FIG. 9—MCINTYRE PORCUPINE MILL

The proposed change in the system will eliminate the filter altogether and use continuous counter-current decantation as described above in connection with the Porcupine Crown mill.

Despite the presence of much schist in the ore, settlement is reasonably rapid as shown by the fact that 150 tons per day has been handled by a Dorr thickener 30 ft. in diameter and 12 ft. deep.

Zinc dust precipitation has been in use at this mill, precipitating 3½ tons of $2.50 to $3 solution per ton of ore. The precipitate is given an acid treatment, then fluxed with soda, borax, nitre and silica, and melted. The resulting bullion is from 820 to 860 fine. Extraction has been about 95 per cent. Milling cost has averaged from $1.30 to $1.35 per ton, of which $0.50 was for supplies, $0.46 for labor, $0.30 for power, and $0.04 for assaying.

A detailed statement of cost and supplies is given in the following table:

| Supplies | Cost per ton |
|---|---|
| Cyanide | $0.080 |
| Zinc | .075 |
| Lime | .012 |
| Crushers and rolls | .010 |
| Hardinge balls and liners | .071 |
| Tube mill (El Oro liner and pebbles) | .035 |
| Clarifying gold solution | .012 |
| Belting, oil and miscellaneous | .054 |
| Filtering | .033 |
| Pumping and elevating | .027 |
| General repair parts | .028 |
| Refining | .063 |
| | $0.500 |

The use of continuous decantation without filters was first proved successful in the Porcupine district at the Porcupine Crown mill. Since then it has been adopted by the McIntyre and Vipond, and the Hollinger is to add a 300-ton unit on this basis. The Tough-Oakes in the Kirkland Lake district is also considering the addition of such a plant to its present stamp-amalgamation mill. On the whole the system seems to be meeting the requirements in this district and is likely to be more extensively adopted.

For courtesies extended while in the Porcupine district we wish to express our thanks to local engineers generally, and particularly to Messrs. F. C. Languth and W. F. Battersby, of the Dome; M. W. Summerhayes, of the Porcupine Crown, and R. J. Ennis and A. Dorfman, of the McIntyre.

# Chicago Convention of American Institute of Metals

At the opening session of the annual convention of the American Institute of Metals, which was held in Chicago on Sept. 8 jointly with the American Foundrymen's Association, Mr. G. H. Clamer, the president, gave a short sketch of the rise of the society. He said that the Institute was an offshoot of the American Foundrymen's Association. It was organized in Philadelphia in 1907 as the American Brass Founders' Association. Four years later the scope of the society was enlarged to include all non-ferrous foundrymen and the name was changed to American Institute of Metals.

At the succeeding sessions of the convention on September 8-11, the program embracing the reading and discussion of a large number of interesting papers was carried out. There was also a banquet of the allied foundry associations at the Hotel LaSalle on Sept. 10 and an industrial excursion, given under the auspices of the Chicago Association of Commerce, on Sept. 11. The American Foundrymen's Association held a convention at the same time, and the Foundry and Machine Exhibition Company gave its ninth annual exhibit at the International Amphitheater, Chicago, during the convention week.

### The New Officers

At the concluding session on Sept. 11 the constitution was revised so that the ten vice-presidents shall be selected from districts representing all of the United States and Canada. Some changes in dues are proposed, but these must be passed upon by the executive committee.

Officers were elected as follows: President, Mr. G. H. Clamer, Ajax Metal Company, Philadelphia; vice-presidents, Messrs. Robert S. B. Wallace, National Cash Register Company, Dayton; W. G. Harris, Canada Metal Company, Toronto; Robert Job, Milton Hersey Company, Montreal; Jesse L. Jones, Oakmont, Pa.; George C. Stone, New Jersey Zinc Company, New York; W. H. Bassett, American Brass Company, Waterbury, Conn.; Fred Moerl, Pullman Company, Chicago; Jacob G. Kasjens, Brass Foundry Company, Peoria, Ill.; H. W. Gillett, United States Bureau of Mines, Washington, D. C.; E. B. Horne, Packard Motor Car Company, Detroit; secretary-treasurer, W. M. Corse, Buffalo, N. Y.

The registered attendance was about 100. The papers relating to metallurgy, metallography and melting practice were discussed on Sept. 10 and 11. In introducing the papers relating to metallurgy of copper, zinc, tin and antimony President Clamer said that there was a great deal of uncertainty among users as to the exact metal content and characteristics of these metals.

### Commercial Classification of Refined Copper

The paper by Mr. Lawrence Addicks, of Douglas, Arizona, on the above subject points out that the world's copper supply comes from four main sources, sulphide ores, oxidized ores, native ores and scrap.

Perhaps the chief chemical characteristic of copper is its affinity for sulphur and the largest deposits of copper ores consist of more or less complex sulphides.

Metallurgically there are three typical processes for producing crude or unrefined copper from the ore, based on the general principles of oxidising sulphides and reducing oxides—(*a*) roasting, smelting and converting, (*b*) alternate oxidation and reduction and (*c*) direct reduction of oxidized ores.

(*a*) which is a strongly oxidizing process by which the great majority of the American production is made from sulphide ores, results in the almost complete elimination of impurities which have volatile oxides, including some of the worst enemies of refined copper, such as arsenic. Converter bar nearly always runs 99 per cent copper plus silver and is not likely to carry more than a few hundredths of a per cent of any impurity but nickel. (*b*) is the old Welsh process, still used to some extent abroad, based upon the reaction between copper oxides and sulphides to eliminate sulphur as sulphur dioxide gas and carried out in a long series of roasts and fusions in reverberatory furnaces. The removal of impurities is here imperfect although they may be to a certain extent segregated in a portion of the product, whence the origin of the "Best Selected" copper of Great Britain. When the ores are wholly oxidized the copper may be recovered by direct reduction in a blast furnace (*c*) and as this is a strictly reducing process the resulting black copper seldom runs over 96 per cent, due to iron and other impurities reduced.

Except in the case of "Best Selected" and similar English coppers, all of the products from the foregoing processes are given a further treatment or refining, which may be broadly divided into furnace or fire refining and electrolytic refining.

Fire refining is based upon the scorifying effect of cuprous oxide upon base metals contained in a bath of molten copper. The crude copper is melted in a reverberatory furnace and air blown into the bath. Cuprous oxide rapidly forms and dissolves in the bath, the blowing being stopped at or before the saturation point. In this way oxygen is carried to all parts of the molten bath and when there are any metals present which are more easily oxidized than copper, cuprous oxide is reduced back to copper and the oxide of the impurity is formed. If this oxide is not soluble in the molten copper it will float to the surface where it may be removed by skimming. As copper stands high among metals in the order of nobility the metallic impurities with the exception of the precious metals may be readily removed in theory. In practice while elimination proceeds rapidly while considerable quantities of impurities are present, the rate diminishes until traces are reached which cannot be slagged off with any reasonable amount of scorifying. Therefore furnace refining is limited in its application to relatively pure crude copper unless a low-grade refined copper is contemplated. Less than ten dollars worth of silver and gold per ton will justify electrolytic refining.

Returning to the bath of molten copper which has been skimmed clean, it is necessary to reduce the excess cuprous oxide dissolved, and no better way has yet been devised than the old Welsh process of covering the bath with a protecting layer of charcoal or low-sulphur coke and then forcing the butts of green trees or poles of hardwood beneath the surface by means of suitable tackle. The cuprous oxide is reduced in this way until a normal amount corresponding to an oxygen content of from 0.04 to 0.07 per cent is left when the copper develops its best physical characteristics, the condition of the copper being followed by the appearance of the fracture of small buttons cast in a spoon or "say ladle" which is a sort of ductility test and by the swell or depression of the surface of an ingot as it cools, which indicates the gas content. The copper is then cast by means of one of the several types of ladling machines which have been very successfully developed in recent years.

When the copper is to be electrolytically refined it is first given a rough furnace refining and cast into anode plates, which are then electrolyzed in a strongly acid solution of copper sulphate. The same order of nobility applies, but the great preponderance of copper over the impurities is now an aid as it assists the selective action of the current in depositing only copper at the cathode. Silver and gold are also saved as they are insoluble in the electrolyte chosen and fall to the bottom of the tank as anode mud or slimes to be separately refined and parted.

Copper entering an electrolytic refining entirely loses its identity. Electrolytic cathodes should be very pure. They generally run about 99.95 per cent Cu, much of the missing 0.05 per cent probably being hydrogen. The metallic impurities generally total about 0.02 per cent.

Except for the fact that individual cathodes may vary more or less in impurity content they are ideal material for brass making. Copper producers, however, have never encouraged the sale of cathodes, as there is apt to be some shrinkage in weight during shipment owing to the comparative ease with which nodules or small pieces can be detached either accidentally or intentionally. Also cathode shipments unbalance the work in a refinery in proportion to their magnitude, as melting cathodes into market shapes is a distinct part of the process.

This melting is done in a reverberatory furnace and originally was an exact duplication of the fire refining already described. As the cathode copper is already pure, a simple melting is all that should be required, but molten copper is so susceptible to contamination that until recently the gases from combustion, iron in the rabbles, etc., were absorbed to a sufficient extent to require actual refining. At the present time large quantities of cathodes are being added to the molten charge during ladling and earlier, basic furnaces are being substituted for acid ones, thereby suppressing slag formation, and attention is being paid to keeping coal ashes from blowing over from the firebox, so that a true melting without refining is being approached.

It is well known that cathode copper when drawn into wire will show an electrical conductivity some two per cent higher than the same copper after a subsequent fire refining. This is probably due partly to the fact that chemical impurities in the cathode are chiefly present as a mechanical mixture due to adherence of anode slimes which are dissolved in the copper when melted, making a high resistance matrix around the copper crystals when the metal is cast and cooled; and partly to contamination during melting. It seems probable that the conductivity of perfectly pure soft copper is in the neighborhood of 103 per cent of the Matthiessen standard in common use.

Lake ores are low-grade native copper deposits, which are mechanically concentrated to an 85 per cent mineral. High-conductivity Lake copper (from the surface ores) cannot be distinguished from electrolytic copper, while low-conductivity Lake copper (from increasing mine depths) is really an alloy of copper with arsenic which has certain desirable properties for special uses. Nearly all the elements which markedly depress the conductivity when alloyed with copper are helpful in developing desirable mechanical properties, for example, phosphorus, aluminium, and silica. High arsenical copper running about 0.4 per cent arsenic has now a special market for making firebox plates in Germany, and uses are found for the intermediate grades.

One of the large Lake companies maintains its own electrolytic refinery, and in this way recovers a small amount of silver and eliminates the arsenic, the product still being classed on the market as Lake, although it is equally electrolytic. The old prejudice in favor of Lake on general principles has now largely died out but only with the contemporaneous retirement of the older generation of wire mill managers. Lake copper should be clearly graded by arsenic contents into a series of alloy coppers, the class at one end competing with electrolytic on its own ground, and the other classes sold in competition with arsenical copper from other sources, a field which has only lately been properly appreciated.

The last class of copper produced, which is considered by Mr. Addicks, is that generally known as casting copper, "a very loose term covering a multitude of sins." Specifications for Lake and electrolytic copper may be readily drawn and after a thorough investigation the American Society for Testing Materials has issued a set which should be generally accepted by engineers, as it has already been by the large refineries and wire mills. Casting copper presents a specification problem hopeless of solution at the present time.

In the second part of his paper Mr. Addicks considers the uses of copper. Electrical uses immediately impose a conductivity requirement which rules out everything but electrolytic and high-conductivity Lake, which, as stated, are practically identical coppers. Most of the electrolytic refineries figure on averaging about 100 per cent soft in the electrical conductivity of their outputs. Occasional lots may reach nearly to 101.0 per cent and some may approach 99.0 per cent, while 98.5 per cent is the usual rejection limit, but it is very unusual for a refinery to ship anything for electrical use which is below 99.0 per cent.

No distinction is made between cakes, wirebars and ingots, more than one shape often being cast from a single furnace charge, so that there is nothing to be gained by ordering wirebars, and then cutting them up when ingots are desired. Unless electrical use is specified it is customary to allow an additional leeway of one per cent in conductivity to the refiner, but he rarely needs this and prefers to maintain the higher standard, as copper is often resold several times before it comes into the hands of the actual user.

When copper is not to be put to an electrical use conductivity is of no special value except as a certificate of the absence of more than a trace of a certain class of impurities. The refiner divides impurities into three classes; those that depress conductivity, such as arsenic and antimony; those that impair ductility, such as lead, tellurium and bismuth; and those which are of value if reclaimed, such as silver, gold, platinum and palladium. The elements which depress conductivity are kept within bounds by the conductivity test regularly made. Those which are of value if reclaimed will never reach quantities sufficient to affect the physical properties of the copper as it would pay to re-refine any such copper. The remaining class comprising elements which impair ductility is more difficult to deal with. We know that bismuth, lead, tellurium and probably selenium make copper very brittle even when present in very small quantities. We do not know, however, how to write a specification limiting these impurities as the presence of small amounts of other impurities will neutralize their bad effects. We do know that amounts of lead up to 0.005 per cent have no perceptible effect in mill practice or in alloys. Double this amount shows mild effects. Lead is about the only one of the group ever met with in sufficient quantity to be of interest. As these elements are practically insoluble in copper their effect on the conductivity is proportional to the amount and consequently negligible.

A representative analysis of refined electrolytic copper of 100 per cent conductivity (annealed) is as follows: copper 99.93 per cent, oxygen 0.04, nickel 0.004, iron 0.0035, sulphur 0.003, antimony 0.003, arsenic 0.002, lead 0.002, aluminum 0.001, silver 0.001, selenium 0.0005, tellurium 0.0005, gold 0.00001, phosphorus and bismuth traces.

It will be seen that oxygen is the chief impurity. It has been pretty conclusively shown that too much oxygen makes the copper harder and affects the annealing temperature, the tensile strength of wire, and the number of breaks in a wire machine. This may be due to some surface effects as the "set" surface of a wire bar has a greater oxygen content than the body of the bar and as the oxygen content increases it is possible that this oxidized layer becomes thicker. Another point about high oxygen is that it corresponds to low copper content and to that extent is sold as copper.

In brass making the "set" or "pitch" of the ingot is of no consequence except when the most careful work is done when melting in the foundry to avoid further absorption of oxygen. It is obviously useless to impose rigid conditions upon the refiner if the same conditions are not observed in the remelting and it is only at the largest and best equipped brass foundries that such conditions are even approached. When zinc is introduced into molten copper it acts as a deoxidizing agent, forming zinc oxide. If the copper is kept at very high pitch this source of zinc loss and dirty brass can be greatly diminished and this fact has resulted in a demand for high copper contents in ingots.

It has therefore become a general custom to specify that the copper contents of refined copper shall not be less than 99.88 per cent, which really means 99.90 per cent, allowing 0.02 per cent for assay variations. As this is a rejection point the actual average content is expected to be between 99.92 and 99.94 per cent.

When we come to casting copper a far greater leeway must be allowed as already pointed out. In fact, except in considering the price charged for the material, copper content as but little to do with casting copper. It is best to buy this material on the basis of known brands after finding what brands yield good results in the particular class of work and then insist upon uniform deliveries, judging the material by chemical analysis of the chief impurities.

The physical defects of refined copper are many. Practically all cast copper is porous, doubtless due to the discharge of dissolved gases as the copper cools.

This is analagous to the "piping" of steel ingots but is not so pronounced because copper is cast in a shallow mould instead of on end. These microscopic bubbles are doubtless the cause of roughness in wire. Then there is a class of defects inseparable from ladling, consisting of cold sets and splashes where the copper has run up on the mould and chilled before the main body of metal reaches that point. Then there is porosity or sponginess of the surface due to the mould being either too hot or too cold. Another defect is raised edges on the set surface, generally due to slightly lowered pitch corresponding to excessive oxygen content of the copper. Should the pitch drop still lower "nigger heads" or little black spots will appear. These are the outlets of gas cavities extending some distance into the copper. On the other hand, should the oxygen content be too low the surface of the bar rises and finally breaks open or "spews," an even worse condition.

Many of these defects are always present in more or less degree. Mechanically ladled copper can never be perfect. Specifications require that copper shall be free from mechanical defects, but a reasonable attitude regarding minor troubles on individual pieces is generally necessary to the peace of mind of a buyer. On the other hand, a refinery occasionally becomes careless in such matters and will send out some surprisingly bad work, so that careful systematic inspection combined with an attitude of friendly criticism is the best way for a copper producer and a copper user to live together.

In Mr. Addicks' absence the paper was read by Secretary Corse. In the discussion which followed President Clamer asked why Lake copper sells at a premium over electrolytic if there is no actual difference.

Mr. W. H. Bassett, of the American Brass Company, Waterbury, Conn., in answer, said that the electrolytic people contend that there should be no premium. The Lake people have argued that inasmuch as Lake copper is a natural deposit it has a longer grain than the electrolytic. Mr. Bassett thinks that probably the whole difference lies in the care with which the product is handled in the refining process. Buyers soon ascertain by experience the reliability of the various producers.

President Clamer said he had heard that if James Cooper had lived Lake copper would not be selling at a premium. When it first appeared electrolytic copper was not of the same good quality as has since been attained by its producers. Perhaps the early prejudice against this copper still exists, although at the present time it is probable that it is only a prejudice. Mr. Clamer spoke of a new process of making brass, in which the zinc is added to the copper in the ladles without reheating.

### The Production of Zinc

Mr. George C. Stone, of the New Jersey Zinc Company, New York, read a paper on "Spelter—Manufacture and Properties." He supplemented it with some reports of tests of various alloys of lead and cadmium with spelter. He also displayed lantern-slide pictures showing how spelter is produced.

The first part of Mr. Stone's paper gives a concise summary of the development of zinc metallurgy and a review of the most representative zinc furnace designs. In the second part the author deals with the impurities in spelter (lead, iron and cadmium) and the effects of these impurities and gives figures on the mechanical strength of spelter. A few notes are added on the limitations of refining processes.

Dr. H. W. Gillett, of Washington, D. C., Mr. Gilbert Rigg, of the New Jersey Zinc Company, and others discussed the properties of various mixtures of cadmium with zinc. The question was discussed whether the occupational disease known as "brass shakes," sometimes experienced by workers in brass foundries, is encountered in zinc smelters. Mr. Stone said he had never heard of a case being caused by pure zinc.

Mr. Bassett said "shakes" do not appear to leave any permanent ill effect, although the attack is disagreeable. Cadmium will give the same symptoms, but more violent.

Dr. Gillett expressed the opinion that copper-vapor poisoning is of a different nature.

### Metallurgy of Tin and Antimony

Mr. William A. Cowan, of the National Lead Company, New York, read a paper on "The Metallurgy of Tin and Antimony."

The first part of Mr. Cowan's paper dealt with tins and gave a summary of representative methods for the analysis of pig-tin for lead, copper, iron, antimony and copper, arsenic, silver, sulphur, phosphorus, tungsten and stannic oxide. This is the outcome of a co-operative analytic research carried out by Mr. D. M. Buck, of the American Sheet & Tin Plate Company, Mr. A. H. Knight, of Liverpool, Mr. A. M. Smoot, of Ledoux & Co., and Mr. J. G. Smith, of the National Lead Company. The different methods of analysis used by the different investigators were described.

The second part of the paper dealt in a similar manner with the metallurgy of antimony and methods of analysis.

At the conclusion of the paper Mr. Cowan made the interesting statement that at the outbreak of the present European war the price of tin rose from 30 cents to 70 cents a pound, but dropped soon after to 35 cents. The price of antimony rose from 5 cents to 15 cents and then dropped to 10 cents. At present the price of tin in New York is about 10 per cent higher than in London. Mr. Cowan illustrated his address with pictures and gave some analyses of samples from ingots of commercial tin and antimony.

President Clamer remarked that the Addicks, Stone and Cowan papers were prepared by authorities on the subjects presented. They are very valuable, for in the case of some of these metals, it is true that very few users know exactly what they have been getting.

### Effects of Repeated Remelting on Copper

In the absence of the author, the paper prepared by Mr. **F. O. Clements**, of the National Cash Register Company, Dayton, Ohio, on "The Effects of Repeated Remelting on Copper" was abstracted by Dr. H. G. Dorsey, of the same company. The interesting experiments described were illustrated by lantern-slide pictures.

The paper gave the results of a series of tests in which the effect of repeated remelting on the soundness of castings was quantitatively measured by an Upton-Lewis fiber stress or endurance machine and chemical tests were made to determine the amount of impurities absorbed during the melting process. The results are given in Table I.

Table I

Physical Data

| | Virgin Metal | First Heat | Second Heat | Third Heat | Fourth Heat | Boron Suboxide | Sample of Boronized Copper Cast Under Ideal Conditions |
|---|---|---|---|---|---|---|---|
| A. B. | 1515 | 850 | 845 | 762 | 334 | 2007 | 3044 |
| R. | 100% | 97% | 96% | 96% | 96% | 103% | 117.5 |
| B. | 2.7% | 5.5% | 4.9% | 8.5% | 22.6% | 2.7% | 0.74 |
| | | | Chemical Data | | | | |
| Copper | 99.78% | 99.59% | 99.49% | 99.43% | 99.39% | 99.56% | |
| Lead | None | Trace | Trace | Trace | Trace | Trace | |
| Sulphur | 0.03% | 0.06% | 0.08% | 0.11% | 0.13% | 0.08% | |

In Table 1 "A B" represents the average number of alternate bends, "R" the resistance offered by the test bar to the bend, given in percentage, assuming the virgin metal to be 100 per cent; "B" the percentage of drop-off of resistance in 10-in. lengths. The toughness of the material is in direct proportion to the figure B.

The last two sets of figures included in table I show very conclusively the value of boron suboxide as a flux. Following the directions of the General Electric Company, two ounces of boron suboxide were added to 16 pounds of the badly injured metal. The copper was heated to 1260° Centigrade, in order to secure the best results from this particular flux. The metal was then allowed to cool down to a casting temperature of 1149° Centigrade, and again cast into ingot form. The ingots had a good appearance, were solid, and the fiber seemed remarkably close, as is evidenced by the results obtained on the endurance machine.

Still again, through the courtesy of the General Electric Company, results are given from a small casting of boronized copper produced under ideal conditions. The copper was both melted and cast in a vacuum. No admission of air during the entire process—such a process with electric source of heat and boron suboxide as a flux, permits absolutely no contamination from oxygen and sulphur—high quality fibre should be the result.

There was considerable discussion of this paper by President Clamer, Dr. Gillett, Messrs. C. P. Karr, of Pittsburgh, Frank A. Clark, of Rome, N. Y., R. S. B. Wallace, of Dayton, Secretary Corse, and others.

Dr. Gillett said that it was not shown to a certainty that sulphur was the impurity causing the deterioration on remelting.

Mr. Wallace spoke of some recent tests on aluminium that were remarkable. The second melting produced better results than were obtained with the virgin metal. These experiments are still being continued in the laboratory of the National Cash Register Company. No fluxes are used. President Clamer remarked that the discussion was of considerable importance, as the question of the effect of remelting is always an open one between the foundryman and the metallurgist.

### Alloys of Copper, Tin and Zinc

Prof. S. L. Hoyt, of the University of Minnesota, read a paper entitled "The Ternary Alloys of Copper, Tin and Zinc—the Kalchoids." This paper, which was illustrated, was of a scientific and technical character. The constitution of the ternary alloys of copper, tin and zinc up to about 50 per cent zinc and 30 per cent tin was studied both by thermal and micrographical analysis. Before a study of the ternary alloys was taken up, an investigation was made of the two binary systems, copper-tin and copper-zinc. The chief results are as follows:

A new heat effect was discovered in the pure copper-tin alloys of the $\alpha + \beta$ range, at 590 deg. C.

In general, the ternary alloys of copper-tin-zinc, up to 50 per cent zinc and 30 per cent tin, were seen from microscopical analyses to behave similarly to the binary alloys of copper-tin and copper-zinc.

The liquidus surfaces, the limit of saturation of the $\alpha$ solid solution, and the eutectoid lines and surfaces were determined.

The eutectoid surface was found to have a maximum near the middle, corresponding to 66 per cent copper, 17 per cent tin, 17 per cent zinc and 590 deg. C. on the eutectoid line. This line shows the $\beta$ solid solutions to be isomorphous.

The addition of tin to the brasses causes the visible breakdown of the $\beta$ solution. The amount of the tin necessary varies with the zinc content and with the rate of cooling through the critical range. This gives rise to abnormalities in the microstructure as explained above.

A field of the $\alpha + \beta$ range in the bronzes was found, in which two heat effects in the solid were recorded, corresponding to the pure copper-tin alloys.

In the discussion Dr. Gillett spoke of the importance of the work of Professor Hoyt in relation to the composition of bronzes. Mr. Clamer spoke of mixtures used in the alloys employed for bearings by railroads, and the importance of knowing the effect of zinc in copper-tin mixtures. Mr. Frank mentioned the fact that zinc and phosphorus do not mix well.

### Melting Practice and the Use of the Electric Furnace in Brass Foundries

Several papers related to melting practice, particularly the use of the electric furnace in brass foundries. The first paper on this subject was read by Dr. **Herbert G. Dorsey**, of the National Cash Register Company. The speaker described "Tests on Electric Furnaces for Brass Foundries." The furnace under test was a 100-kg one of the Helberger type, made by the Allgemeine Elektricitaets Gesellschaft of Germany. Dr. Dorsey described the construction of the furnace and the tests made with this furnace under operating conditions. His final conclusions are as follows:

"Considered commercially, from our standpoint this furnace is a failure. It shows many disadvantages and very few advantages. As a laboratory furnace, including experimental work in the foundry on new combinations, it possibly is a good type of furnace, provided a suitable crucible can be obtained, because almost any temperature may be reached and easily maintained for any considerable length of time, and if only a few heats were to be made per week, the occasional renewing of crucible, resistor, plates, etc., would not be bothersome. To prevent contamination of the metal, some other crucible material would be necessary. On fifty-five heats, five different crucibles were used on an average of only eleven heats per crucible. Working at the above basis no more than eleven or twelve heats could be melted per day unless the furnace were operated at night which would mean a new crucible every day. Unless an air blast were used, to cool it, the furnace would scarcely get cool enough during the night to insert the crucible the next morning. Assuming ideal conditions it would require about 31 kw hours per cwt. to melt the metal, while the above tests show about 62 kw hours per cwt.

"Another disadvantage of the furnace is the fact that the crucible is long and narrow and it is difficult to charge the metal in any quantity unless the furnace tender stayed right with it and put it in piece by piece. This would mean that it would require one tender for each furnace which would be rather expensive. In a more convenient form, the crucible would be a short cylinder of large diameter, but electrically this would be bad as it would necessitate greater currents.

"These tests seem to eliminate the Helberger furnace in our own foundry as a competitor with pit fires. We are now working with other types of furnaces, but have not yet had trials enough to reach any conclusions."

Dr. Gillett said that this paper gave the first account of commercial work with the electric furnace in a brass foundry. Because the Helberger furnace did not succeed under the conditions of the work at Dayton, it does not follow that all electric furnaces are inefficient. Dr. Gillett also pointed out that in considering electric-furnace operation the energy needed to heat the furnace before work is begun must be taken into consideration.

### Electric Furnace for Medium Temperature

A paper on this subject was contributed by Mr. Ernst M. Schmelz, of Detroit. It was read by Secretary Corse and described a furnace which is an evolution of the well-known Stassano type of steel furnace, being built on the same principle, with such particular features added as the lower melting temperature of the charge requires. An experimeneal furnace of this type has been tested at the plant of the Titanium Alloys Manufacturing Company at Niagara Falls, N. Y., Mr. N. Petinot of this company being one of the patenters.

Figs. 1 and 2 show a longitudinal and a cross-sectional view of the furnace. The melting chamber is lined with magnesite, and has an oval section consisting of a semicircular bottom and top, and two straight side walls. There is also an outer lining of fire brick, and the whole furnace is enclosed in a steel shell, and either stationary on its base or supended on two trunions in case it is desirable to use a tilting arrangement instead of the tapping hole.

The heating medium employed is the pure electric arc created between the points of two or more electrodes which enter the furnace from the side. At the points of entering there are water-cooled jackets for the protection of the electrode holders the details of which are shown in Fig. 3. These electrode holders have to be protected from excessive heat and therefore are built hollow and contain an inner tube electrically insulated, from the other parts of the electrode holder, which tube is connected with a water-cooling system. The regulation of the electrode is affected by small hydraulic cylinders placed underneath the water jackets. They are double-acting and governed by four-way cocks mounted on a little standard beside the furnace.

It is evident that if water under pressure is admitted behind the piston of the hydraulic cylinder, this piston and the piston rod will move out and thereby force the electrode holder, with which it is rigidly connected, to move in the same direction, and increase the space between the electrode points. This causes a decrease in the amount of amperage, entering the furnace at a given constant voltage, and correspondingly decreases the heat in the furnace. The reverse movement of the piston will, of course, have the contrary effect, and by this simple and quick-acting system a perfect and smooth regulation of the furnace operations is assured, doing away with all complicated electric starting and regulating apparatus.

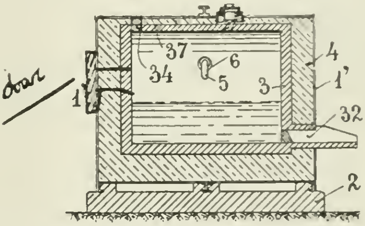


FIG. 1—SECTION OF MEDIUM-TEMPERATURE ELECTRIC FURNACE

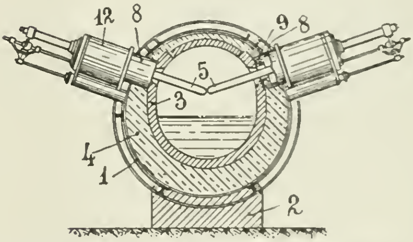


FIG. 2—SECTION OF MEDIUM-TEMPERATURE ELECTRIC FURNACE

To protect the charge from an excessive heat the electric arc is placed approximately in the center of the open space between the surface of the bath and the roof, and on the other hand to prevent a rapid destruction of the roof, and the second or outer lining is much thinner where it covers the roof than on the bottom part of the furnace, owing to the eccentric location of the melting chamber in regard to the outer shell.

The raw material is brought into the furnace through one or more charging doors in the sides which can be tightly closed, which arrangement in combination with the air-tight construction of the electrode holders and stuffing boxes admitting the electrodes affords the special feature of this furnace of a complete neutral atmosphere during the whole time of operation.

In regard to the practical use of this furnace it has several obvious advantages over any ordinary melting furnace using oil or gas as fuel. The use of electricity, the only absolutely pure heating medium, prevents the introduction of any impurities like sulphur, etc., fom the fuel into the charge and the hermetically closed melting chamber affords a complete control over the total process from a metallurgical point of view. Both these features unite in keeping the heat efficiency far above the one obtainable in an open-draft furnace.

An experimental furnace of 120 kw melted 1000 pounds of red copper in less than two hours, using 240 kw-hours per ton of metal, or 0.12 kw-hour per pound. A larger type will, of course, show a tendency to decrase the melting time as well as the amount of electric energy used per ton of molten metal.

The furnace can be designed for the use of D. C. or A. C. current, either single or three-phase and with a voltage of 75 to 220 volts, according to the size of the furnace. The number of cycles is immaterial. The power factor is high, 90 per cent and higher.

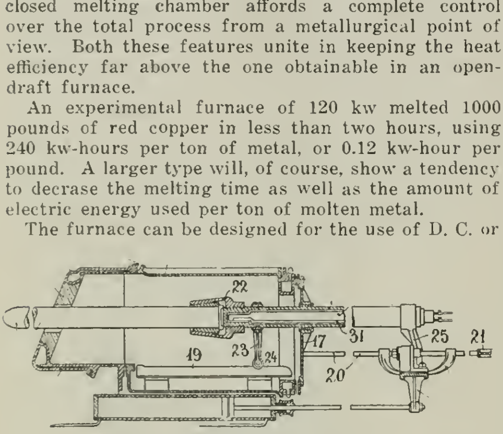


FIG. 3—ELECTRODE HOLDER DESIGN

The regulation is simple and uses no electrical apparatus, but only a hydraulic arrangement, working on about 30 pounds pressure, which are obtainable most anywhere by simple connection with the city water system. No special transformers or starters are required and the furnace can be operated on any private or public lighting and power plant without fear of disturbing other users.

The upkeep of the furnace is economical, the repairs of the lining can easily be done at night or over Sunday and the electrode consumption is small on account of the closed melting chamber, which prevents any excessive burning out of electrode material under the influence of the oxygen of the air.

Dr. Gillett said in the discussion that it was probable that greater uniformity of metal could be obtained by using the electric furnace than in the case of the fuel-fired furnace. One use of the electric furnace is in the melting of cathode copper as produced by electrolytic copper refining. While open to conviction, the speaker expressed himself as skeptical in relation to arc furnaces for melting copper and zinc. The arc-furnace people should produce their figures.

As to frequency, Mr. Corse said that he understood that 25-cycle energy was all right for melting copper. Mr. Corse added that he understood that Mr. Petinot had had some trouble caused by the rapid destruction of his electrodes.

Dr. Dorsey said that so far as he had learned arc furnaces are not adapted to brass melting.

### The Central-Station Point of View

Mr. H. M. St. John, of the Commonwealth Edison Company, Chicago, read a paper on "Electric Brass Melting from the Central-Station Viewpoint." The larger central station companies are rapidly becoming convinced that it is worth while in many instances to give a helping hand in the experimental development of promising processes which use electric power. With respect to the use of electric furnaces for melting brass, as with other processes of a similar nature, it is the mission of the central-station company to act in an advisory capacity to its customers. In order to fill such a role intelligently it is necessary to do a great deal of investigation and experimental work. The needs of the customer must be accurately known and the central-station man must be able to recommend the furnace and method of operation which most satisfactorily meet his peculiar requirements.

The largest single item of cost is the cost of the electric power. Two distinct types of furnace will find use, the "crucible lift-out" type in which the metal is melted in a crucible which is lifted bodily from the furnace and carried to the moulds when the metal is ready to pour, and the tilting type, in which the metal is melted in the furnace chamber and poured into a heated ladle when ready for use. In general the tilting type is the more efficient, but for certain purposes the crucible type is preferred despite its lower efficiency.

The author gives in Table II the results of preliminary tests made on two furnaces, one of the crucible lift-out and one of the tilting type, and gives an estimate as to the approximate power requirements per ton under three systems of operation: (1) Continuous operation for 24 hours a day, (2) ten-hour operation, and (3) "special ten-hour operation" in which case some power is maintained during the night sufficient to keep the furnace hot.

**Table II—Approximate Power Per Ton**

| Metal. | Mode of Operation. | KW Hours Per Ton<br>Lift-out Furn. | <br>Tilting Furn. |
|---|---|---|---|
| Yellow Brass | Continuous | 400 | 280 |
| Yellow Brass | 10 hour | 580 | 400 |
| Yellow Brass | Special 10 hr. | 540 | 397 |
| Red Brass | Continuous | 500 | 350 |
| Red Brass | 10 hour | 720 | 500 |
| Red Brass | Special 10 hr. | 640 | 467 |

In further tables costs of power are given for the regular power rates of the Commonwealth Edison Company of Chicago and an approximate comparison of melting costs is made between fuel and electric furnaces. From the figures obtained the following general conclusions are drawn:

"The ordinary oil lift-out furnace will hardly turn out more than eight heats, or about 0.8 of a ton per 10-hour day. If the furnaces are kept hot over night the electric lift-out furnace will increase this by 25 per cent, the tilting furnace by 50 per cent. The net cost of melting is such that the electric lift-out furnace can be used to considerable advantage in melting yellow brass where continuous or 20-hour operation is practicable. When the furnace is kept hot over night the electric furnace, working 10 hours per day, shows a net cost of melting so close to that of oil that increased production and improved working conditions may be considered factors of sufficient importance to swing the balance in its favor. The electric lift-out furnace does not make a good showing in melting red brass; the tilting furnace is much better adapted for this work.

"In melting yellow brass the tilting electric furnace is more economical than oil under any conditions of operation, and its saving is very marked with either red or yellow brass if continuous or 20-hour operation is used. Special 10-hour operation shows a melting cost for red brass a little higher than of oil, but greatly increased production and improvement in working conditions are in its favor.

"To sum up the present situation, the writer believes that we are safe in saying that a reliable electric melting furnace can be used to advantage wherever 20 or 24-hour operation is possible and in many cases where the regular 10-hour day is the rule. It is well to remember also that the electric brass furnace has at this time only started to realize the possibilities of its development and its reliability and efficiency are sure to be largely increased in the near future."

At the conclusion of the paper President Clamer said that proprietors of small brass foundries could not think of installing electrical generating plants to supply energy for electric furnaces. The electric service companies are greatly interested in this subject. It sounded like a foundryman's dream to have the heat come into the establishment over a few wires.

Mr. Frank Schutz, foundry foreman of the H. Mueller Manufacturing Company, Decatur, Ill., gave it as his opinion that it is only a matter of a short time when all brass founders will be using electric furnaces. He said that difficulties were encountered when the oil-fired furnace was first used, but these have been overcome. Similarly, the electric furnace will make its way.

### Economy of the Electric Furnace

The government Bureau of Mines is studying the metal losses which are encountered during the melting of brass and other non-ferrous alloys in the effort to find methods of reducing these losses. Dr. H. W. Gillett is the alloy chemist of the Bureau of Mines, and he presented a paper on the subject, "Melting Losses in Electric Brass Furnaces," prepared by himself and Mr. J. M. Lohr.

The authors first give a review of the melting losses in fuel-fired brass furnaces on the basis of Bulletin 73 of the Bureau of Mines (H. W. Gillett, Brass Furnace Practice in the United States). The metal losses on non-ferrous alloys fall into two classes; first, losses due to metal entrained in the slag and skimmed off before pouring, and to the spilling of metal in pouring or to spilling metal over into the ashes or coal or coke furnaces during melting and to the spilling of metal in pouring. This class of losses are not primarily due to the furnace, but to a greater or less degree of carelessness in the operation of melting and pouring. These losses can be minimized by care.

The second class of losses, however, is due to the conditions in the furnace itself. These losses are due to oxidation of the metal melted while in the furnace, and to the volatilization of zinc from zinc-containing alloys. Metal lost in these ways is not recovered.

Figures of the losses are given as they occur in actual practice under best conditions of operation as well as under average conditions.

There are two main problems requiring solution before electric furnace for brass melting can be put on a commercial basis: First, is the melting loss sufficiently reduced by electric melting to give it a real advantage on that score over the common methods? Second, can the electrical efficiency of any type of furnace which had advantages in regard to metal losses be made high enough so that the cost of power is not prohibitive?

All electric furnaces for brass melting are still distinctly in the experimental and development stage. Hence the development of electric brass melting has not at present progressed far enough to justify a discussion of the various types in regard to the second problem above outlined.

The Bureau of Mines, in its study of electric furnaces for brass melting has, however, made a number of tests on several types of furnaces with particular attention to the question of metal losses. The results are given in the present paper.

From tests with an indirect arc furnace it is concluded that while it is quite possible that an indirect arc furnace may be so designed and run as to give low zinc losses, yet on account of the high temperature of the arc, it will require careful operation to avoid local over-heating and to reduce the losses below those of fuel-fired furnaces. The tests cannot be considered conclusive on this type of furnace, but so far do not look at all promising on the score of metal losses.

On the other hand, tests of an overhead resistor furnace and the crucible lift-out furnace give loss figures on all the alloys tested that show a considerable saving over the losses of even the best run fuel-fired furnaces.

"The figures given on the crucible lift-out furnace can doubtless be duplicated or closely approached on any form of electric furnace that can be tightly closed and in which there is not excessive local overheating. Crucible furnaces with a carborundum resistor and the Hering furnace should give losses of the same order of magnitude as those in the tests cited, although in these furnaces where no carbon monoxide is given off through oxidation of the resistor, it may be necessary to keep the atmosphere of the furnace chamber reducing by some means such as that of dropping in oil, suggested by Fitzgerald, in order to prevent oxidation of the charge. Tilting furnaces will probably give a slightly higher loss, not because of greater loss during melting itself, but because the metal is more exposed to the air and there is more opportunity for volatilization of zinc, during the double pouring from furnace to ladle and from ladle to mold, than in the single pouring from crucible to mold in a crucible lift-out furnace.

"While the problem is not yet settled in regard to arc furnaces, the data set forth in this paper shows that on a number of types of electric furnaces the metal losses, particularly from alloys high in zinc, are very low, as they should be, according to theory. The figures are sufficiently encouraging to make the development of electric furnaces for brass melting worth the time and labor it will take to bring them to the point where the power consumption is low enough to allow them to compete on an over-all cost basis, with fuel-fired furnaces, and thus allow the brass industry to stop the drain on our mineral resources that is now being made by the metal losses in brass melting."

The bulk of the work was done on brass having 16 per cent of zinc, which was poured at about 1,200 deg. Cent. The net result was that it was found that the losses were reduced to one-half or one-third of what they would be in good practice with fuel-fired furnaces. Dr. Gillett remarked that to get good efficiency the electric furnace must be run pretty fast. In his judgment, it is going to pay the brass founder to buy electrical energy, because the resulting saving will show in economy. Co-operation between the founders, the electric furnace builders and the central-station people is needed and is, indeed, in evidence. But it is to be remembered that the electric furnace for the brass foundry has not yet been sufficiently tested, so that the savings mentioned in the paper may be obtained under foundry conditions. There is still much experimental work to be done. Manufacturers are wisely holding back electric furnaces until they are perfected.

The advent of the electric furnace in the brass foundry will be slow but sure. However, it will never compete with fuel-fired furnaces where metals are now melted down without loss or with losses of less than 1 per cent. But where, as with many of the non-ferrous metals, the losses in melting are a large factor, the electric furnace gives promise of effecting a saving. In fact, the electric furnace in brass melting is no longer a wild hope, but may be regarded as a certainty.

President Clamer said that Dr. Gillett's work was of great value to the industries represented in the American Institute of Metals.

### Use of Gas in Brass Melting

Mr. **E. B. Guenther**, of Detroit, gave an abstract of a long paper entitled "The Use of Producer Gas for Melting Yellow Brass." The paper gave the result of tests conducted jointly by the Detroit Copper & Brass Rolling Mills Company and the Westinghouse Machine Company on a producer gas-heated furnace in the casting shop of the former company. Mr. Guenther did not seem to have much use for the electric furnace. He declared that there is at least one plant where producer gas is used for melting brass under commercial conditions, whereas there is not one in which the electric furnace is used. A gentleman connected with the Langsenkamp plant, where producer gas is used both for engine drive and for fuel in furnaces, said that the coal used is Pocahontas mine run and that the consumption is 8 tons a day.

Mr. **Fred L. Wolf**, of the Ohio Brass Company, Mansfield, Ohio, gave the substance of a paper prepared by himself and Mr. **Robert B. Burr**, entitled "Tests of Natural Gas-Fired Brass-Melting Furnaces Under Factory Operating Conditions." The object of these tests was to endeavor to increase the efficiency of the furnace by making use of the present equipment without entering into too great an expense for alterations. The gas was obtained from the medium pressure mains. The air necessary for combustion was obtained from an independent blower outfit which was installed so that any air pressure up to 32 ounces could be obtained at will, as the highest available pressure, under factory conditions when all equipment was in use, was approximately 14 ounces. The results of our tests showed that by a proper burner construction and manipulation, as efficient results could be obtained with 4 ounces of gas and 14 ounces of air, as with higher pressures, and with, of course, a consequent reduction in the cost of compressing the air.

The experience of the authors shows that where the shell or drum of the ordinary pit type of coke furnace is sufficiently large to allow a reasonable thickness of lining this furnace equipped with a simple tube burner and pre-heating coils, which allows the use of low pressure gas and air, is as efficient as any of the more complicated furnaces tested. Its maintenance cost is practically nil, which applies to the burner also, and our experience shows that it may be continuously operated without delay for repairs and with no inconvenience to operators.

### Pyrometers

Dr. H. W. Gillett summarized an exhaustive paper he had written on the subject of "Pyrometers for Molten Brass and Bronze," in which radiation pyrometers, optical pyrometers and thermo-electric pyrometers are classified. He described an improved thermo-electric instrument in which a composite protective tube is used, the body being silfrax, but provided with a tip of molybdenum, which is not attacked by hot molten brass or bronze. However, according to the speaker, there is not yet any pyrometer which can be considered an all-around practical foundry tool.

### Electric Brass Melting with the Hering Furnace

Mr. **G. H. Clamer**, of Philadelphia, gave, in brief abstract, a paper written by himself and Dr. Carl Hering on "Electric Brass Melting."

In the paper the general advantages of electric furnaces for brass melting are first discussed, and it is pointed out that the ideal method would be to melt and pour as quickly as possible, hence in as small lots as the particular conditions of the foundry require, though this, of course, need not be carried to extremes. It is thought, however, that for small castings at least a high power tilting brass furnace of this type could be constructed small enough to be transported to the molds, pouring directly into them.

A description of the general construction of the Hering pinch-effect furnace is then given, and it is pointed out what a large amount of heat is carried out of the heating holes in the furnace bottom ("the resistors") effectively by the rapidly flowing metal; it exceeds that of a row of electric arcs in those holes. At present about 25 to 50 kw. are converted into heat in each hole (or roughly about 90,000 to 200,000 B. T. U. or 20,000 to 45,000 kg. cal. per hour), with the probabilities that this can be considerably increased. The correct proportioning of these holes and the current are of great importance. These proportions are quite different for brass than for steel. The furnace must be especially designed for each metal, though variations in the compositions of brasses and bronzes can be taken care of in the same furnace by regulation of the electric current.

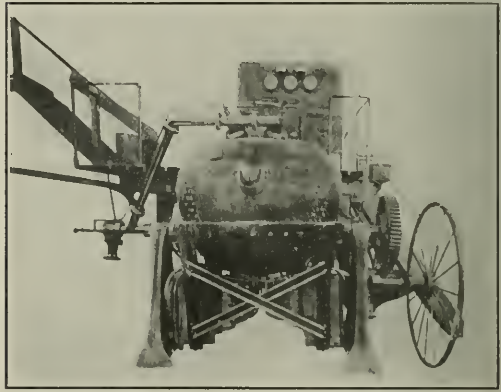


FIG. 4—TWO-PHASE PINCH EFFECT FURNACE

Even copper with its very low resistance can be melted commercially in these furnaces without requiring impractical proportions. The higher the electrical resistivity of a metal the better the proportions become.

The power factor of the furnace, even with 60 cycles, is not low, being "in the eighties and nineties, and even this small reduction from 100 per cent was no doubt largely, if not all, in the transformers and could be avoided in a better design of the transformers. In a steel furnace with a frequency of 25 the power factor was practically 100 per cent, hence perfect."

The Hering furnace has so far been used for melting very light brass and bronze chips, which gave trouble in the fuel furnaces. In melting many tons of these light, curly and oily brass chips with much mechanically mixed iron, they cast in the form of clean ingots nearly 8 pounds per kw. hour, delivered to the furnace transformers, equal to about 12.5 kw. hours per 100 pounds poured. But there were various losses which can be avoided in future. Short runs, with clean ingot charges, indicated that, even with the easily avoidable excesses in the losses, 10 pounds per kw. hour could be obtained in this furnace, hence, in better designs, even still better efficiencies than this can reasonably be expected. But this figure depends largely on the amount of superheat required by the particular foundryman.

The economy of the electric melting could be greatly increased by preheating the charge with a fuel flame, preferably in an auxiliary furnace, to only such a temperature at which no oxidation takes place.

E—Electric Cooling Block
S—Secondary Lead
B—Plumbago Blocks
R—Resistor Holes
H—Plumbago Hoods
P—Water Pipes
L—Electrode Lugs

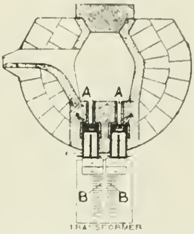


FIG. 5—JACKET AND ELECTRIC CONNECT FOR 120-KW TWO-PHASE PINCH EFFECT BRASS FURNACE

Comparisons are then made between the operation costs of fuel-fired and electric furnaces for brass melting. Finding as an average 38 cents per 100 pounds for coke furnaces and 20 for the electric, the saving in a plant melting 20 tons per day, would be nearly $22,000 per year of 300 days; or for oil furnaces at 43.2 and electric at 20 cents, the saving would be nearly $28,000 per year, which should be credited to the first cost of the electric furnace.

The development of the Hering type of furnace involved many difficulties largely because it was an entirely new and somewhat radical departure from existing practice, hence no precedents existed. The troubles encountered in its development were chiefly in finding the proper proportions of the electric parts for which no precedents existed and which could be determined only by trial, involving the erection and destruction of many experimental furnaces. The electric resistivities of the molten metals had to be determined as they were not then known to the art. The electrodes, which are of metal, are necessarily liquid at their hot ends and solid at the cold ends, hence must be carefully designed and proportioned, so that on the one hand they do not melt back too far, and on the other hand do not carry off too much of the heat. The undesirable circulation or washing of the metal at the hot ends of the electrodes where they join the heating holes has been avoided by a special construction of the electrodes.

The outside of the 110 kw. furnace is shown in Fig. 4. It is a two-phase furnace. The two transformers are seen underneath; they tilt with the furnace. For each transformer there are two vertical heating holes, thus making each transformer independent of the other. A three-phase furnace with three transformers, three electrodes and three heating holes would be better.

Fig. 5 is an outline and diagrammatic vertical cross section in which R are the heating holes or resistors.

In a later and better design the hearth, electrodes and heating holes are arranged as in Fig. 6, which makes the relining and repairs of the heating holes easier than when they are at the bottom, as they are in Figs. 4 and 5. This improved form also permits turning around the spout as a center, which is considered by many to be an important advantage, and which does not exist in the form in Fig. 4.

The furnace shown in Fig. 4 has been criticised for being so large outside. These large outside dimensions are not essential and the furnace could have been made far smaller for the same capacity of metal if desired or by using an outside lining of kieselguhr brick. But thick walls economize heat, which is more important in electric than in fuel furnaces, as the cost per unit of heat is, of course, greater. Our argument was that bricks are cheaper than kilowatts, hence that the first investment in thicker walls was more economical than to suffer the continued losses of expensive kilowatts.

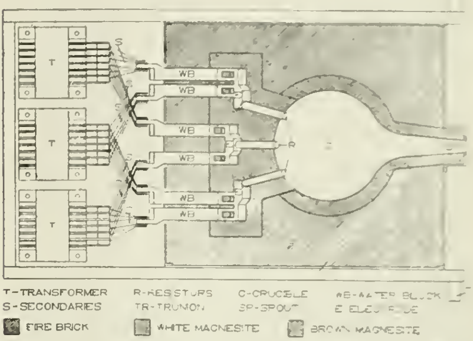


FIG. 6—150-KW THREE-PHASE PINCH EFFECT FURNACE

The Hering furnace will soon be in regular, 24 hours per day, operation at the foundry of the Ajax Metal Company in Philadelphia, they having made very satisfactory terms with the local power supply company.

Reports of a number of other papers had to be reserved for our next issue.

## A New Aluminium Alloy

A London company has placed on the market a new alloy named "Ormiston Metal," after its inventor, Mr. H. O. Ormiston, of Sydney, Australia. The metal, which is white and bright, contains about 97.5 per cent of aluminium, and can be produced either directly from bauxite clay with the addition of the requisite chemical compounds, or by alloying pure aluminium. It is stated that this metal will take a polish equal to that of silver or nickel, which it retains permanently, and that it is not corroded by the atmosphere, by sea air or by food acids. For equal weights its electrical conductivity is greater than that of copper or any known alloy. Tensile tests taken at the National Physical Laboratory show a strength of 16 tons per square inch, and tests in Australia went up to 20 tons. Perhaps the most important claim is that it can be soldered either to itself or to other metals with an ordinary soldering iron or blow-lamp and can be brazed or welded without difficulty.

---

**Transvaal Gold Production.**—The number of companies reporting to the Transvaal Chamber of Mines in June, 1914, was 60. The total quantity of ore milled during that period was 2,233,507 tons. There were 9,803 stamps in operation with an average duty of 8.82 tons per 24 hours. Tube mills in commission numbered 294. The yield for the month was 717,926 fine ounces gold.

# Notes on Chemistry and Metallurgy in Great Britain

*(From Our Special Correspondent)*

### The War and the Engineering Industries

Considerable dislocation of most of the British industries inevitably occurred during the first two weeks of the war, but there are manifest signs that the difficulties are being grappled with firmly and will soon be overcome. In the steel trade, particularly in Scotland, the cessation of the supply of continental material has been rather severely felt by engineers and shipbuilders, while the supplies of ore for the furnaces are by no means equal to the demand. In the Tyne district there has naturally been a large increase of work in the shipyards, and the Elswick works are as busy as they can be. At Sheffield some of the works not engaged in the production of war material have been put on short time, but the increased activity of those that are so engaged compensates for the temporary adverse condition of the others. In South Wales there is every prospect that the iron and steel industries may anticipate a period of renewed prosperity, and probably a considerably higher output than has ever been previously attained. Birmingham, of course, produces a great output of war material, and large orders from government have been placed with the Birmingham Small Arms Company and other concerns.

Mechanical engineers in general are not so lucky, and the wholesale cancelling of orders has been acutely felt. In the Swansea district the tin-plate workers may safely look forward to a vastly improved condition of affairs. More than 100 tin-plate mills in this neighborhood will shortly be re-started, and it is estimated they will employ upward of 5000 hands. The engineers of Liverpool are more fortunate than some of the others. A large influx of government orders has been keeping practically all the works very busy, while there is every sign that this brisk state of affairs is likely to continue for a considerable time.

As a result of the ability of the British navy to keep practically the whole of the trade routes at sea free from interference, the alarm which was so general during the first week or two of the war has almost totally subsided, and it is not too much to hope that the British engineering industries will very soon resume a condition, not perhaps quite normal, but at all events approaching it.

### The Féry Gas Calorimeter

The determination of the calorific value of gas involves, at present, the use of expensive and intricate apparatus under expert supervision, as well as the expenditure of considerable time. M. Féry, the inventor of the well-known pyrometer bearing his name, has now produced a simple instrument which gives a quick and, apparently, a reliable reading. When a flame is inclosed in a chimney the current of the gaseous products of combustion admixed with surplus air has a velocity proportional to the calorific value of the material undergoing combustion. The new instrument consists of a burner and chimney with a cylinder below through which all the air passes; while at the lower end of the cylinder an anemometer is suspended, by its gravitic center, and by angular displacement, indicates the velocity—and, consequently, also the calorific value—on a calibrated scale. The accuracy of the determinations depends on the gas being supplied at a strictly uniform rate, and to ensure this a sensitive governor regulates the flow.

### The Supply of Tungsten

Several months ago it was pointed out in these notes that Great Britain was dependent on Germany for practically the whole of the supply of tungsten. But the question of the production of tungsten in England has already been under serious consideration by influential firms connected with the steel trade, and the Luton firm which has for some time past devoted its attention to the production of ferrotungsten and similar alloys will soon be in a position to assist in meeting the requirements of manufacturers of tool steel and other special steels.

### The Iron and Steel Institute

The meeting of the Iron and Steel Institute which was to have been held in Paris in September will, necessarily, now not take place. There were hopes that the assembly would be transferred to London; but it has been decided to abandon the meeting altogether. The papers will be sent to the members by post, and criticisms in writing will take the place of the usual discussions, and will be duly published.

### The Institution of Mining Engineers

The annual meeting will be held on Sept. 9 at Stoke-on-Trent. The following papers are included in those put down for reading: "Absorption of Oxygen by Coal," by Messrs. T. F. Winmill and J. I. Graham; "Self-Contained Rescue Apparatus and Smoke Helmets for Use in Irrespirable Atmospheres," by Dr. J. S. Haldane, and "Unknown Clays in Coal Mines," by Dr. J. W. Mellor. Sir William Garforth will preside.

### The Distribution of Phosphorus in Steel

Among the papers presented in the Engineering Section of the recent Australian meeting of the British Association was one by Dr. W. Rosenhain describing a method of treating steel specimens, elaborated by himself and Mr. J. L. Haughton, which, they claim, brings out structural features much more satisfactorily than do the ordinary etching processes.

The author remarked that, while the deteriorating effect of phosphorus on the mechanical properties of steel is unquestionable, it is hardly credible that less than 0.04 per cent of phosphorus could exert a serious effect if it were uniformly distributed throughout the metal. The reagent employed in their research was a solution of ferric chloride acidified with hydrochloric acid and with the further addition of small proportions of chlorides of copper and tin; and its action was to replace the small amount of iron dissolved from the specimen by an equivalent quantity of copper.

With a steel of ideal purity the film of copper would be quite uniformly deposited on the ferrite, but in the case of steel containing phosphorus compounds the purest portions of the surface are coated first and those parts richest in phosphorus are left bare for a considerable time. When carried to a certain point the appearance of the surface developed by the etching corresponds almost exactly, under the microscope, to that produced by heat-tinting, but with less prolonged action features are brought out which are not revealed by the etching reagents usually employed or by heat-tinting.

From a close examination of these features the author has been led to attribute the origin of the banded structure of phosphoric steel to processes occurring during the first solidification of a solid solution alloy; and he concludes that the coarseness or fineness of the banding in the finished steel is determined by the scale of crystallization which occurred in the original ingot, although the crystalline structure may have subsequently undergone repeated modification by thermal or mechanical treatment.

### Manganese Steel

Among the several Iron and Steel Institute papers which have not yet been reported, one on manganese steel should first be mentioned.

A paper by Sir R. A. Hadfield and Professor Bertram Hopkinson described the magnetic and mechanical properties of the manganese steel containing 12 pe rcent of manganese and 1.25 per cent carbon. When heated to 1000 deg. C. and quenched in water the steel is very tough and almost non-magnetic, but when reheated in the neighborhood of 520 deg. C. for about 600 hours, it will acquire a degree of magnetism about 60 per cent of that exhibited by pure iron. It also requires magnetic properties at lower temperatures, but the change is very much slower.

It was found that the magnetism acquired at 520 deg. C. was not got rid of nor diminished by reheating at 550 deg. C., but that at higher temperatures than 640 deg. there was a rapid diminution and the magnetism was almost completely eliminated after heating for a few minutes at 750 deg. C. Heating curves demonstrated that this sudden change of properties at about 700 deg. was accompanied by a perceptible absorption of heat.

This manganese steel, after cooling in the ordinary way in air, subsequent to casting or forging, is somewhat brittle, hard, and non-magnetic: after quenching in water from 1000 deg. C. it is very ductile but remains non-magnetic, and any treatment of the water-quenched-steel which renders it magnetic to only a slight extent also tends to make it hard and brittle, and when it has acquired one per cent. of the magnetism of pure iron it has lost its toughness to such an extent as to be useless for ordinary purposes.

The hardness generally increases with the magnetism, but the increase in hardness is not comparable with the hardness acquired as a consequence of the accession of the initial traces of magnetism.

Well defined changes in the micro-structure occur during the transition from the ductile to the hard and brittle condition.

### Cause of the Hardening of Metals

In a paper by Professors C. A. Edwards and H. C. H. Carpenter the authors contend that the process of annealing or softening metals by heating to fairly high temperatures and subsequent slow cooling results in the extensive growth of crystals. When alloys, such as carbon steels are quenched, severe stresses are induced which cause marked twinning of the crystals. The greater hardness brought about by quenching steels from a temperature above their highest critical point is directly as the velocity and thermal extent of the suppressed inversion; and the relation between crystal twinning and percentage of carbon is plainly evident.

Dr. Beilby showed that when metals are depressed and hardened by cold working amorphous layers are found on the surface, and similar amorphous layers are found on all surfaces on which twinning takes place. The authors are of opinion that the presence of these amorphous layers is the ultimate cause of hardening by quenching steels. From these effects it appears that the cause of hardening by quenching is precisely similar to that of hardening by cold working, namely, the internal deformation of crystals.

### Direct Production of Steel from Ore

A paper by Messrs. Ernest Humbert and Axel Hethey dealt with the direct production of steel from ore in the electric furnace. The difficulties experienced in the ordinary manufacture of steel in getting rid of oxygen, phosphorous, sulphur, and silicon and the practical impossibility of eliminating hydrogen and nitrogen induced them to experiment on a method of producing steel of a higher degree of purity. They arrived at the conclusion that under satisfactory conditions the electric furnace is suitable for the practical production of high-grade steel direct from the ore; and they claim that the predominent feature of the steel manufactured in their experiments is its great toughness. Forge tests carried out at the furnace showed that even when containing a high percentage of carbon the steel would easily bend without fracture.

### Utilization of the Heat of Molten Slag

The Slag Power Company seems, to a very great extent, to have solved the question of using up the heat in furnace slag. Experiments have been carried on for about four years at Messrs. Bell Brothers' works at Port Clarence, and at last all the difficulties which were encountered in the early stages appear to have been effectually overcome.

The original idea was to use the steam directly produced by the immersion of the slag in water, but the presence of sulphuretted hydrogen, sulphur and other impurities rendered the use of such steam inadmissible in a turbine, and no efficient process could be devised for the removal of those impurities. The method now adopted is to use this impure steam generated by the immersion of the slag in the water to supply heat to a Kestner single-effect climbing film evaporator, and the apparatus has been brought to such a state of perfection that the results are very satisfactory.

It has been ascertained that 1 kg. of slag contains about 550 calories, or 1000 kg. would contain 550,000 calories, and after allowing for loss by the heat remaining at 100 deg. C. and the heat in the water absorbed by the slag, estimated at 50 per cent., the net value of 1000 kg. would be 490,000 calories which a further allowance for working loss brings down to some 367,500, which is equivalent to 590 kg. of steam.

In actual practice more than 740 kg. of water have been evaporated by 1000 kg. of furnace slag, and the average efficiency of the evaporator is approximately 91 per cent; but even at 80 per cent. the pure steam which could be used for turbines amounts to 472 kg., which, with a steam consumption of 13 kg. per horse power is equivalent to 36 horse power per 1000 kg. of iron slag.

Of course, in estimating the economy, the cost of the plant and labor have to be taken into consideration, and when the steam thus generated is used in a low-pressure turbine it is estimated that with a 1000 k.w. plant working at 75 per cent load, the generation of one k.w. would cost 0.32d. as against 0.48d. with a high pressure steam plant and coal at 14s. 6d. a ton, showing a saving of 0.16d. per k.w. in favor of the slag plant—a difference which is calculated to amount to about £4,300 a year at the works in question

### A New Thermopile

The practical difficulties hitherto encountered in the production of a thermopile capable of yielding an efficient and useful supply of electrical energy have been such that the instrument has been almost lost sight of amongst practical men for many years. It has remained for Johannes Marschall, of Dresden to produce a thermopile in which the old difficulties have to a very great extent been overcome, and which promises to be a serviceable source of current to small consumers of electrical energy. In the Marschall pile the positive elements are made of a special alloy of low resistance and high E. M. F., whilst the negatives are of constantan, an alloy of copper and nickel, the junction being made with electro-deposited copper. Five such pairs in series form one section, and the requisite number of sections are arranged in an annular frame with the heated junctions on the inside and the cold junctions on the outside. The required output is obtained by employing a sufficient number of rings arranged in a central heating tube.

But a leading feature of Herr Marschall's apparatus is the furnace which acts as a gas generator in which the gas produced from coal or other suitable fuel is conveyed to the central heating tube, where, admixed with a plentiful supply of air, it undergoes perfect combustion. In the annular space on the outside of the rings of sections cold air is made to circulate at a speed sufficient to maintain the required temperature. Experiments with a pile consisting of ten sections working with the difference of 300 deg. C. between the hot and the cold junctions show an E. M. F. of 0.03 volt per pair.

On this basis it is estimated that a pile containing 1000 pairs would give 1.5 kilowatts at 35 volts, and would measure about 3 ft. in diameter by 7 ft. in length. A pile giving an output of about one kilowatt has been at work for some little time in Dresden, and so far no deterioration has been observed in regard to resistance at the junctions. If the claims which are put forward for the efficiency of this pile should prove valid, as appears probable, the apparatus will be very serviceable for lighting and small power installations, particularly in country districts remote from any power station. There is a growing demand for such an apparatus. But at present we have no information as to either capital outlay or working costs.

### Revised Engineering Standards Specifications

The British Engineering Standards Committee has recently issued a report (No. 68) revising the specifications for the resistance of steel conductor rails for electrified railways. The resistance is to be stated in terms of a rail of the same material as the conductor-rail having a length of 1 yd. and weighing 100 lb. Conversion tables for resistances measured at a given temperature in rails of other weight are appended, together with formulæ for ascertaining in terms of the new standard the equivalents of the resistances of rails expressed in terms of copper, as formerly.

Specification No. 65 provides that pipes hitherto known as "stoneware" pipes shall be described as "salt-glazed ware" pipes. There are two classes of these, viz., "Standard Pipes," made to comply with the specification, only a certain percentage of which need be actually tested by hydraulic pressure, and "Standard Tested Pipes," every one of which must undergo hydraulic test.

All pipes complying with the B. E. S. specification are to have a standard mark.

### Marine Oil Engines and Fire Risk from Sprayed Oil

The Board of Trade inquiry into the loss by fire of the small motor vessel *Scout*, on Loch Leven, last August, resulted in experiments being conducted by one of the board's surveyors which afforded some very instructive conclusions which fully justified the adjournment of the proceedings in order to ascertain whether oil projected from the flywheel of an engine of the type used on the *Scout* would ignite and cause the firing of the boat. The engine room and engine of the *Scout* were reconstructed as nearly as possible, and it was found that when running at 450 r.p.m. any oil that was in the bilge was thrown by the flywheel on to the exhaust pipe. If it were pure lubricating oil it did not ignite from contact with the exhaust pipe, but was vaporized in dense smoke which could be ignited by a naked flame. When glowing points left by burned cotton waste were put on the hot exhaust the oil caught fire, but not readily. With oil of lower gravity and flash point, such as paraffine, in the bilge the spray from the flywheel took fire immediately on coming into contact with the hot pipe.

The court found that the fire which destroyed the *Scout* was so caused.

The danger to be apprehended from sprayed oil is not confined to small boats having engines fitted with flywheels, but extends to all highly heated pipes and machinery where oils of low gravity are employed.

### Public Companies

*Anderston Foundry Co., Ltd.:*

A final dividend of 15/6d. per share is recommended, making £1 per share for the year, less income tax. £40,984 is placed to depreciation and £10,000 withdrawn from the reserve fund four years ago are replaced. The dividend for the previous year was 12s. per share.

*British Electric Traction Co., Ltd.:*

A dividend is recommended of 3½ per cent on the 7 per cent non-cumulative preferred stock, as well as a full dividend on the 6 per cent cumulative preference stock. £50,000 is carried to reserve.

*Marconi Wireless Telegraph Co., Ltd.*—The ordinary general meeting was held July 21 when Commendatore G. Marconi, who presided, said he was afraid the report and figures had been somewhat disappointing to the shareholders; but, from the criticisms he had heard and seen, he judged that the report and the figures it contained had not been correctly apprehended. The reason why the directors recommended a final dividend of 10 per cent was the fact that the large sum of £142,726 5s. 11d. carried forward at the end of 1912 was carried forward for the purpose of averaging dividends after placing £100,000 to special reserve account. Some of the remarks during the discussion were distinctly of an acrimonious character; but the general feeling of the meeting may be gauged from the almost unanimous expression of confidence in the chairman and the board which followed the offers of resignation by the chairman and the managing director.

### Market Prices—August, 1914

The official exchanges being closed, prices are not fixed, and can only be taken as representing private transactions and liable to change at any time. Those given below must be taken with all reserve, and show merely that, owing to precautionary measures, the possibility of violent fluctuations has been avoided.

The London Metal Exchange, after being closed from July 30, reopened from Aug. 18 from 11:30 a. m. until 12:30 p. m., and has been so opened since, but dealings and the making of prices were prohibited, and press publication forbidden.

| | £. s. d |
|---|---|
| Aluminum ingots, ton lots | 85. 0. 0 |
| Copper sulphate, cwt | 17/6 to 18. 6 |
| Caustic soda, 70%, cwt | 9/9 to 10. 3 |
| India Rubber, Para, fine, lb. | 2.10 |
| Petroleum, Russian spot, gal | 9¼ |
| Lead, ton | 21. 0 0 |
| Copper | 58. 2. 6 |

Best selected copper was quoted as follows during the month:

| | £ | £ | |
|---|---|---|---|
| July 31st | 60 | -61 | per ton |
| Aug. 4th | 60 | -61 | " " |
| " 7th | 64½ | -65½ | " " |
| " 11th | 65 | -66 | " " |
| " 14th | 64 | -65 | " " |
| " 18th | 63 | -64 | " " |
| " 21st | 61 | -62 | " " |
| " 25th | 60 | -61 | " " |

# Synopsis of Chemical and Metallurgical Literature

## Gold and Silver

**Nipissing Mill and Metallurgical Practice.**—A discussion by Mr. G. H. Clevenger at the Salt Lake meeting of the A. I. M. E. of a paper previously presented to the Institute by Mr. James Johnston. After outlining the status of metallurgical practice at Cobalt prior to the researches by the Nipissing company, Mr. Clevenger states that it was the determination of the Nipissing consulting metallurgists to treat all ore by a hydrometallurgical process and that nothing but refined silver was to leave the premises. The middle ground involving concentration and cyanidation did not appear attractive. "Generally you are attempting to operate a concentrator and a cyanide plant with neither up to full efficiency.". Concentration in combination with cyanidation should be adopted only as a last resort.

The results of preliminary tests indicated that a cyanide plant would be most advantageous. The use of mercury in the low-grade mill was not attractive, and the plan of grinding the whole ore, native silver, dyscrasite, etc., fine enough so that all the silver could be dissolved by cyanide, was finally adopted. Usually when metallic gold and silver occur in ores that are to be cyanided, amalgamation or concentration are resorted to; but in this case the native metal was finely ground for cyanidation. This is a point on which there may be a strong difference of opinion, and which must be determined by conditions.

The author points out that the idea of using a preliminary treatment involving the use of aluminium and caustic soda on precious-metal ores, such as is done at Nipissing, is not new. It was suggested by W. H. Walker in a note on the electrometallurgy of gold, published in the *Transactions* of the American Electrochemical Society, volume four, 1903. This preliminary reduction may not be economically feasible on all ores, and the author urges caution in its adoption. Thus in the Cripple Creek district, where roasting is cheaply done, the wet reduction process might not be profitably adopted, but where roasting cost on telluride ores was high the wet reduction method would merit consideration. In some cases wet reduction might form products that would interfere with cyanide treatment or cause a high cyanide loss. Again, preliminary treatment with caustic soda alone has proven valuable.

Although precipitation by aluminium dust was finally adopted at Nipissing, the author is not convinced that zinc precipitation would have been impossible. The application of aluminium dust precipitation elsewhere must be considered cautiously. Probably its future use will be confined to special cases. One of the difficulties encountered in using this precipitant is the long period of violent agitation necessary, due to a coating of the oxide and stearine, the latter being used in the manufacture of the dust.

The author gives consideration to the relative merits of zinc and aluminium as precipitants and discusses the claim for cyanide regenerated by the use of aluminium. He points out also the chemical value of zinc in cyanide solutions, as potassium zinc cyanide, and the gradual regeneration of cyanide in alkaline cyanide solutions that have been precipitated on zinc.

**Descriptive Technology of Gold and Silver Metallurgy.**—A paper presented at the Salt Lake meeting of the A. I. M. E. by Mr. A. W. Allen, in which the author deals with some inconsistencies of expression used by technical writers and points out fallacies in the presentation of metallurgical results. On the subject of "extraction," the point is made that "extraction and recovery are terms which are not necessarily interchangeable and the time is ripe for due recognition of the fact." The author objects to certain loose methods of calculating and reporting recoveries in metallurgical processes, and points out the necessity of clarity of statement so that comparisons can be made between operations at different mills.

The following definitions are suggested, and formulae given for obtaining the desired results:

**The assay or theoretical extraction** is the amount of metal which is indicated by assay results as having been removed from the ore during treatment.

Where $a$ = the assay of feed,
$z$ = the assay of residue, and
$t$ = the tonnage represented,

$$\text{then } \frac{100\,(a - z)}{a} = \textit{percentage assay extraction.}$$

$$\text{and } \frac{a_1t_1 + a_2t_2 + a_3t_3 + \ldots}{t_1 + t_2 + t_3 + \ldots} = \text{average feed assay} = A,$$

$$\text{and } \frac{z_1t_1 + z_2t_2 + z_3t_3 + \ldots}{t_1 + t_2 + t_3 + \ldots} = \text{average residue assay} = Z$$

$$\text{then } \frac{100\,(A - Z)}{A} = \textit{average assay extraction percentage.}$$

**The actual extraction** indicates the amount of metal recovered from the ore and isolated either as bullion or in other concentrated form. Such actual extraction is estimated by the direct valuation of the bullion and the statement of return from smelter or buyer showing actual metal content in concentrated product, upon which sale was effected.

Where $M$ = the amount of metal in bullion, concentrate, or precipitate,
$T$ = the tonnage milled,
$t$ = the tonnage of concentrated product removed, and
$Z$ = the average actual residue assay,

$$\text{then } \frac{100\,M}{M + Z\,(T - t)} = \text{average actual extraction percentage.}$$

**The actual recovery** can only be based on the direct valuation of bullion, and the term is only available for use when the bullion produced is approximately the same market value, *per se*, as the contained gold and silver.

Where $M$ = the amount of metal in bullion,
$T$ = the total tonnage, and
$Z$ = the average residue assay,

$$\text{then } \frac{100\,M}{M + TZ} = \textit{average actual recovery percentage.}$$

In the statement of working costs, the author urges the segregation of working cost from general expense, and the differentiation between the cost of repairs and renewals. In the statement of construction costs he suggests the exclusion of all sums paid for wearing parts, these being segregated in a suspense account and charged out as operating expense. Attention to these details will prevent large fluctuations in costs and avoid false impressions.

## Copper, Lead and Zinc

**Unit Construction Costs of the Arizona Copper Company's Smelter.**—Probably no paper presented at the Salt Lake meeting of the A. I. M. E. received more commendation than did that of Mr. **E. Horton Jones**, in which unit costs of smelter construction were given. The paper was spoken of as a classic of its kind. Naturally no abstract can be given, and reference must be had to the original paper published in the July *Bulletin* of the Institute. The actual figures are of interest primarily to smelters, but all classes of metallurgists will be interested in the manner of presenting these cost data, and will gain a great deal by studying the article. The subject is presented under five heads: unit costs, comparative costs, composite costs, wage scale and raw material prices. Each cost item is described, and numerous drawings illustrate the types of construction.

**Nodulizing Blast-Furnace Flue-Dust.**—Experience with a 6-ft. by 60-ft. rotary, oil-fired kiln is given in the July *Bulletin*, A. I. M. E., by **Mr. Lawrence Addicks.** Preliminary experiments in a 2-ft. by 20-ft. kiln indicated a fuel consumption of 50 gal. of oil per ton of dust nodulized. Excellent nodules were formed and rings or accretions were absent. In the larger kiln in actual operation, fuel consumption was greatly reduced and rings showed a marked tendency to form. A first-class smelting product could be made with an oil consumption of 12 gal. per ton. The inclination of the kiln was $\frac{5}{8}$ in. per foot, and the speed $1\frac{1}{2}$ r.p.m. Capacity varied: with a clean kiln it was possible to nodulize 75 tons of dust in 24 hours; a choked barrel reduced the capacity half, but regular operation delivered an average of 50 tons per day, including all delays. Experiments with coal firing, operating after the manner of a gas producer, was a failure owing to irregularity in the temperature at the mouth of the kiln. Coal-dust firing was not tried as it gives too high a temperature for nodulizing. The author believes that kiln-nodulizing is worthy of wider use, but suggests that its applicability can be determined only by experiment. "The crux of the whole matter lies in cost of fuel."

**Basic-Lined Converter Practice at the Old Dominion Plant.**—Conditions at the Old Dominion smelter make it necessary to crowd the converter capacity to its limit, and interfere with the systematic operation of the converter. **Mr. L. O. Howard** gives the following record of converter operation, in a paper presented at the Salt Lake meeting of the A. I. M. E.

| | |
|---|---|
| Commenced blowing | Jan. 6, 1913 |
| Taken off stand for patching | June 27, 1913 |
| Total blowing time | 2,689 hr. 40 min. |
| Total number of blows made | 664 |
| Average time of blow | 4 hr. 3 min. |
| Tons matte charged | 18,157 |
| Average copper content of matte | 43.9 per cent. |
| Average time blowing one ton copper | 22.5 min. |
| Total copper made | 7,250 tons |
| Average copper per converter hour | 2.66 tons |
| Average air used per minute | 9,000 cu. ft. |
| Average blast pressure | 13.3 lb. |
| Ore fed | 3,301 tons |

| *Average Slag Analysis* | | *Average Matte Analysis* | |
|---|---|---|---|
| | Per Cent. | | Per Cent. |
| Cu | 2.5 | Cu | 43.9 |
| $SiO_2$ | 22.7 | Fe | 28.8 |
| Fe | 52.1 | S | 22.6 |
| CaO | 0.8 | Ins | 0.4 |
| $Al_2O_3$ | 1.6 | | |

The author describes a difficulty encountered in the closing of the converter mouth due to cooling of the charge when it was necessary to pour from the converter directly into molds at a time when the casting machine was out of commission. Various means were tried for removing the incrustations, but none proved effective until a specially designed collar puller was adopted. This device is lowered into the mouth of the converter from the crane. On lifting, a cutting tooth is forced into the incrustation, loosening it until large pieces can be removed.

Experience with the formation of monolithic magnetite lining on the basic brick is also described.[*] Following is the method used at Old Dominion for applying the magnetite coating: Into a new converter previously heated by coal and coke, charge about 12 tons of molten matte and blow for about 3 hours with silica. Then lower the temperature by the addition of about 4 tons of cold hood cleanings and blow for a short time, when the magnetite will be spread evenly over the interior. More matte and just enough silica to flux the iron therein contained are then added, and the charge finished in the usual manner. The magnetite lining is then maintained by attention to the temperature of converting.

**Smelting Lead Ores in the Blast Furnace.**—In a paper on this subject by **Mr. Irving A. Palmer,** published in the July *Bulletin* of the A. I. M. E., the author calls attention of the modified policy of one of the largest lead smelting companies regarding publication of details of its technical operations, and commends the abandonment of secrecy in this respect. The paper covers many details of lead smelting, and the original must be consulted to get the greatest benefit. Of first importance in the progress in lead smelting in recent years is the adoption of sinter-roasting, as in Huntington-Heberlein pots and Dwight-Lloyd continuous machines. Second in importance is the general use of mechanical methods in handling materials. The bag house has been more generally adopted, and larger furnaces are being built. Water jackets are of soft steel instead of cast iron. Mechanical feeding has been more generally adopted, and the charges are more thoroughly mixed than formerly. In discussing the effect of different ingredients in the charge and the formation of slags and mattes, the author points out the necessity of looking for metal losses elsewhere than in the slag, and suggests that lead is a very elusive metal when in the form of fume.

**The Bag House in Lead Metallurgy.**—In a paper presented at the Salt Lake meeting of the A. I. M. E., **Mr. L. Douglass Anderson,** superintendent of the Midvale smelter of the U. S. Smelting Co., discusses the complete bag house system adopted at that plant in order to minimize damage to agricultural crops in Salt Lake valley. Both blast furnace and roaster gases are thus collected separately. The former present no difficulties, but the latter are hot and contain more or less sulphuric acid, and must be cooled and neutralized. The importance of cooling cannot be underestimated if metal recovery is to be complete. Cooling can be accomplished by passing the gases through thin metal flues, by water sprays and by dilution with external air. Neutralization is done by introducing lime, zinc oxide, or other suitable base into the flues.

The introduction of the bag house has resulted in the accumulation of many elements, such as arsenic, cadmium, tellurium and selenium, which formerly escaped, but which now increase in quantity if a closed circuit is maintained for any length of time by resmelting bag-house residues. At Midvale the arsenic is allowed to build up until the dust is rich enough for treatment in arsenic furnaces for the recovery of white arsenic.

The author mentions the experience with Dwight-Lloyd machines, and the bag-house fires which resulted from the distillation of elemental sulphur into the flue gases. This condition was marked in damp weather and disappeared in warm dry weather. Various schemes were tried to avoid this condition, but they were ineffective. Finally the use of these machines was limited to sintering pre-roasted matte and ores low in pyrite.

**Lead-Matte Converting at Tooele.**—A modification of the usual method of converting leady matte has been adopted at the Tooele smelter of the Internation company. The process was described in a paper read by **Mr. Oscar M. Kuchs** at the Salt Lake meeting of the A. I. M. E. At first it was endeavored to convert copper-lead matte in the usual manner, with the direct addition of silicious fluxing ores; but bag-house troubles developed in the form of acid spots on the bags, resulting in their ultimate destruction. This meant that either the converter fumes must be neutralized by CaO or ZnO, or the production of a fume in itself sufficiently alkaline to prevent the deposition of free acid in the bags. Hence the method was changed, and molten matte directly from the blast furnaces is now blown without the addition of silicious flux, to the almost complete elimination of the lead, and to the production of copper bullion. The lead fume is collected in the bag house, and the copper bullion and heavy iron slag are transferred to converters blowing copper matte. This reduces the copper oxide formed in the first blow of the lead-matte charge, and utilizes the value of the iron slag for fluxing silicious ores. The final slag from the copper converters is then transferred molten to a reverberatory copper furnace. This system has greatly improved conditions in the bag house.

---

[*] Originally described by Wheeler & Krejci, *Bulletin* A. I. M. E., Dec., 1913. See also this journal, Feb., 1914, p. 138.

**Losses of Zinc in Mining, Milling and Smelting.**—In the symposium on zinc metallurgy at the Salt Lake meeting of the A. I. M. E., Messrs. **D. A. Lyon** and **S. S. Arentz** presented a paper in which they discussed the present losses of zinc and the probable methods for reducing such losses. It is stated that probably less than 50 per cent of the zinc mined reaches the form of spelter. The methods of beneficiating and smelting zinc ores are briefly discussed, and the possible future sources of zinc are given, as follows: Present waste in concentration processes, waste in slags of lead and copper smelters, low-grade carbonates, and micro-crystalline ores of zinc, iron and lead.

**Ammonia-Carbon Dioxide Process for Complex Zinc Ores.**—Another paper in the zinc symposium was that of Mr. **S. E. Bretherton**, who advocated the use of the ammonia-carbon dioxide process for the treatment of zinc ores containing precious as well as other base metals. Briefly the process is as follows: Grind the ore, roast, regrind, leach zinc with ammonia and carbon dioxide, precipitate copper from the zinc solution, distill ammonia and carbon dioxide from the solution, thereby precipitating basic zinc carbonate which can then be calcined to oxide. The precipitated copper can be added to the residue, which is then ready for smelting. The basic zinc carbonate can be smelted, or converted into chloride for use as a wood preservative. If the oxide can be made pure white, it can be used as a pigment. The author concludes his paper with a detailed report on test runs in an experimental plant.

## Chemical Engineering.

**Ammonia Analysis.**—In an article by **E. Stach** in *Glückauf* of Aug. 1, 1914,, various new apparatus are described for determining and recording the pressure, speed, and the density of gases and vapors, besides an instrument for determining the ammonia content in liquids. The principle of the latter instrument is that when ammonia is decomposed by hypobromites or hypochlorites, nitrogen is developed in gas form in a quantity proportional to the ammonia to be determined. The equation for an ammonium chloride solution with sodium hypobromite $3NaBrO + 2NaOH + 2NH_4Cl = 2N + 2NaCl + 5H_2O + 3NaBr$. In order to record automatically the result of the analysis the nitrogen set free is measured by the instrument shown in Fig. 1. At *a* the liquid containing the ammonia enters. At *b* the hypobromite is syphoned off. In the measuring vessel *cd* the liquids are kept on a certain level. Through *e* water enters into *fg* and compresses the air in *g* to a pressure which depends on the height of the syphon *h*. This compressed air acts on the liquids in *c* and *d* whereby they are forced into the mixing vessel *i*. Since the compressed air cuts off *k* simultaneously, the nitrogen set free in *i* must pass below the bell *l*, the motion of which is transmitted to the recording drum.

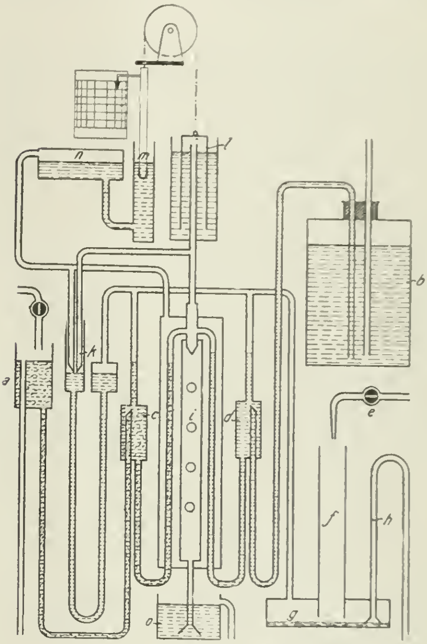


FIG. 1—AMMONIA ANALYSIS

**Sulphuric Acid Towers.**—In the *Chemiker Zeitung* of July 30 Dr. **Georg Schliebs** emphasizes that if sulphuric acid towers are to be substituted for lead chambers, they should be designed and operated accordingly, but this is usually not the case. In the first place, there is not the same opportunity for the gases of getting mixed. In a lead chamber of 1000 to 3000 cubicmeters content the gases remain for half an hour or an hour in continuous motion and mixing, concentrated gases coming in contact with gases which have been already become diluted and so on. Through a tower of 100 to 300 cubicmeters content the gases pass in a few minutes. While there is a perpetual dividing up and reuniting of the gas currents, there is never an opportunity of fresh gases and of diluted gases coming together. In the second place a lead chamber is able to get rid quickly of any excess of heat by simple radiation. The tower has a much smaller radiation surface, moreover, the tower fillings act as a storage or reservoir of heat. Further in a lead chamber the gases are repeatedly heated and cooled, which is impossible in a tower. The author thinks that these disadvantages of the tower can be overcome by the very simple remedy of providing behind the tower an "equalizer" ("Ausgleicher"), that is a vessel in which the acid is removed from the gases, while the gases which are now more dilute and have been cooled may be returned by a special pipe line back to the entrance of the tower so as to pass through it again. He obtains in this way a forced mixing of dilute and of fresh concentrated gases. Further the reaction heat is gotten rid of in a simple way by air or water-cooling. Temperature differences are produced since the warm gases are cooled in the equalizer and are heated again in their next passage through the tower. The output of the different towers and of the whole system may be regulated by this method within wide limits. The towers are better utilized and the expensive supply of acid running down over the filling may be largely reduced. Disturbances in operation and variations in output and temperatures may be equlized before they reach the final towers.

### Radium in Carnotite

**Determination of the Radium: Uranium Ratio in Carnotites.**—The increasing importance of carnotite as the largest known source of radium has made the accurate determination of the radium: uranium ratio in that mineral of the greatest importance. Hitherto investigators have found deviations from the normal ratio, as observed in pitchblende, and the results have usually been low. Hence the impression has gained ground that carnoties are, as a rule, anywhere from a few per cent to 30 per cent lower in radium than would correspond to the uranium content. In order to investigate this matter more carefully, Messrs. **S. C. Lind** and **C. F. Whittemore**, of the Denver office of the Bureau of Mines, conducted a research, the results of which are published in the current issue of the *Journal* of the American Chemical Society. Their work is of great importance to the American radium industry, for they establish the fact that the ratio of radium to uranium in carnotite is identical with that of pitchblende. Their paper describes methods of procedure and gives data on many determinations. Following is a summary:

1.—Samples of carnotite representing *large* quantities of ore (a few hundred pounds to several tons) show a Ra:U ratio identical with that of pitchblende, $3.33 \times 10^{-7}$, which is also in accord with the value calculated from radiation data.

2.—Samples from *small* quantities (hand specimens up to a few pounds) tend to exhibit abnormal ratios, in one instance as low as $2.48 \times 10^{-7}$, and in another as high as $4.6 \times 10^{-7}$.

3.—The most plausible explanation for these ratios seems to be one of "transposition" of radium within an ore bed, producing local differences which are equalized in large samples.

4.—The "emanating power" of carnotite appears high and varies from 16 to 50 per cent.

5.—In order to obtain concordant results by the Boltwood emanation method, it was found desirable to determine the emanation liberated by solution in the same sample from which the emanating power had just been determined, thus making the two determinations strictly "complementary."

6.—Radium may be easily determined by the emanation method in one operation either by solution or by ignition from tubes in which it has been sealed for one month to reach equilibrium.

7.—In contrast with the successful solution or ignition methods for de-emanating carnotite, fusion with carbonate, and also the fusion and solution method both gave low results and were abandoned.

### Corrosion.

**Corrosion of Condenser Tubes.**—A very suggestive article on the corrosion of condenser tubes is contributed to the September issue of the *General Electric Review* by E. Bate, of the New South Wales Government Tramways in Sydney, Australia. The author gives a review of his own experience with pit-hole corrosion. With Rhodin he distinguished between balanced and unbalanced alloys. "Particles of the two constituents of the alloy, infinitesimally close together, will have each a definite solution potential. If these solution potentials balance, then the minimum rate of corrosion is obtained, for if they do not balance, local currents are set up and electrolytic corrosion assists the purely solution or oxidation corrosion. On this theory, and by using the heats of oxidation and molecular weights of copper and zinc, the author arrived at the result that 70 per cent. Cu and 30 per cent. Zn is the best alloy of these two metals." The British Admiralty specifies a mixture of 70 per cent. Cu, 29 per cent. Zn and 1 per cent. Sn.

Its suitability for plants using sea water is, in the opinion of the author, well established. When pit-hole corrosion occurs, however, it is of a local character and is ascribed by the author to local action due to an electronegative particle on a surface positive to it. There seem only two ways in which such a condition can be set up: (1) by segregation in the alloy; (2) by a deposit of electronegative particles on the tube surface. That the second assumption is correct is, at least in his own case, the chief point of the author's discussion and his arguments in this respect are as follows: First, as to the time which it takes for the tube to become pitted completely through he finds that failures start to take place within a month or two after the condenser is put in service, and the average failures per week gradually increase to a steady average rate of failure, with heavy failures now and again. In some cases the trouble may cease after a few months, and the engineer usually concludes that corrosion was due to faulty tubes, which have been eliminated. In several cases the author has found that about the time when failures ceased, some certain treatment of the condensers had been started, which the engineer generally did not connect in any way to the improved conditions. He emphasizes the fact that it is possible to stop failures by methods whose only effect would be to prevent the possible deposit of electronegative material in the tubes, and, furthermore, that the effect is noticeable very rapidly, which points to the fact that corrosion is a phenomenon whose action is very rapid. Further "if corrosion is due to a deposit, then, undoubtedly, we can expect with confidence that the majority of holes will be in the lower half of the tube. This anticipation is most strikingly verified as a result of the author's observations." Of 468 tubes the author found that only 21 had a corrosion hole in the upper half of the tube, the remainder were in the lower half. That corrosion of the tubes under notice took place on the bottom half of the tube has been corroborated by other engineers whose condensers suffered in the same way. Since, therefore, the very strongest grounds were present for suspecting that a dangerous deposit was being left in the tubes, it became important to determine from what source this deposit came.

"The author's attention was directed to the corroding cast iron of the circulating system and condensers as a source of troublesome deposit for the following reasons: Although the circulating water brought through the condensers in question is always very dirty, certain condensers taking the same water have been free from trouble. If, therefore, we consider the water at intake in the harbor as free from deleterious material, the troublesome particles must come from the metal in contact with the water on its way to the condenser. Cast iron, unless carefully protected, corrodes severely when exposed to the action of sea water, and as cast iron is a so-called alloy of carbon and iron with traces of other impurities, the products of corrosion will be mainly oxide of iron and carbon. Carbon is, as previously pointed out, strongly electronegative, and, therefore, of just the nature to cause the trouble experienced. The condensers under particular observation, which gave very serious trouble, were provided with 22 copper stays between tube plate and water box cover at each end, and these copper stays had cast-iron sleeves to form distance pieces between tube plates and covers. There were thus 44 cast-iron distance pieces in the water space of the condenser, all of which were found to be badly corroded, especially close to the tube plate, where they were in close contact with the gun-metal.

To test this theory, the cast-iron distance pieces were removed, and gun-metal distance pieces substituted, while, at the same time, the cast-iron surfaces in contact with circulating water were all cleaned and painted with a protective coating. "The measures above outlined were soon productive of marked diminution in the number of tube failures in these condensers, and it can be definitely stated that, up to the present, no tube put in the condensers since the alterations were made has failed." Stations that take circulating water to the condensers, or to the circulating pump intake in concrete or brick ducts, and use either short cast-iron or entirely gun-metal intakes, should, therefore, not suffer to any appreciable extent from tube corrosion. At the White Bay power-house this policy can be pursued, as the circulating water ducts are entirely of concrete, and the short intake is of gun-metal, the pump body and impeller being of a yellow metal mixture. Inquiries have elicited the information that several plants, which have been free from trouble, have consistently protected their cast iron on general grounds without any idea of thereby preventing the corrosion of condenser tubes. "The author trusts that if the logic of his theory is sound, the result will be a greater confidence in installing large condensing plants, and less anxiety as to the possibility of serious and expensive trouble. It should lead to a modification of those conditions under which large stations draw supplies of sea water through considerable lengths of cast-iron piping, often quite untreated internally, and thus liable to continuous corrosion. The suitability of the Admiralty tube for plants using sea water, when supplied by good makers, is, in the opinion of the author, well established, but tinning of the tube seems unnecessary and dangerous."

---

**Rutile.**—Virginia produced all the American output of rutile in 1913, according to the United States Geological Survey, the deposits being located at Roseland, Nelson County. During the year the company which controls and works these deposits produced 305 tons of rutile, valued at about $49,000. A large part of the rutile produced in 1913 was used in the manufacture of titanium carbide electrodes for arc lamps. A part of the ilmenite found in the deposits and separated by means of amagnetic separator has been sold for use in making electrodes for electric lights, and the experiments with the electric furnace point to the possible use of ilmenite in the direct production of tool steel.

**Tungsten.**—The tungsten resources of the United States are probably considerably larger than have been generally realized. Many new deposits have been discovered in various parts of the Western States, according to the United States Geological Survey, and, should prices advance, it is probable that the output could soon be increased much above the record year of 1910, when 1821 tons were marketed. Most of these new discoveries are not sufficiently developed to show how large an output can be expected from them; but it is probable that some will prove to be of considerable extent, and one or two new large producers would make a noticeable difference in the American market.

## Recent Chemical and Metallurgical Patents

### Iron and Steel

**Briqueting Fine Ore.**—An improved method of briqueting fine iron ore, flue dust and the like, has been patented by **Walter Mathesius**, of Charlottenburg, Germany. The invention consists in the employment of a binding medium which will react with a part of the iron in the material to be briqueted. Alumino-silicates of a highly basic nature are mixed with ferric hydroxide and water, and this binding medium then mixed with fine ore. If the addition of ferric hydroxide has not exceeded a certain limit, the binder will react with further quantities of ferric hydroxide or oxide, and yield products having the properties of a cement. The binder should be mixed with the ore in as fresh a state as possible. The quantity of ferric hydroxide in the binder should not exceed one molecule for each three molecules of the bases contained in the alumino-silicates. From one to two per cent of the alumino-silicates is sufficient to form firm briquets. Portland cement blast furnace slag or like products of calcination or fusion containing the necessary quantity of lime can be used as the basic alumino-silicates. Burnt lime also may be used, but in that case the binder must be formed by grinding the lime with fine iron ore in water, and after heating to accelerate the reaction between iron oxide and lime, mixed in a fresh state with the material to be briqueted. The whole is then molded and allowed to set. In order to lower the fusing point of the briquets and thereby prevent disintegration before fusion, certain addition agents may be used, such as the oxides of magnesium, strontium or barium, or small quantities of titanic acid. (1,104,124, July 21, 1914.)

**A Method of Incorporating Titanium into Iron** has been patented by **Mr. Auguste J. Rossi**, of Niagara Falls, N. Y., and assigned to the Titanium Alloy Manufacturing Co., of New York City. Relatively high temperatures, say 2500 deg. C. or higher, are required for the production of titanium-iron containing relatively high percentages of titanium, say 10 per cent. The inventor has discovered, however, that lower-grade titanium irons, containing say from 5 to 1 per cent of titanium, can be made at temperatures of the open-hearth or blast furnace, say from 1500 to 1700 deg. C., provided there be present, during some stage of the operation, manganese in the elemental state. He cites the fact that titaniferous iron ore containing as high as 40 per cent titanic acid, when smelted in the usual manner, will yield iron containing little or no titanium, but when smelted with manganese in the charge, the resulting iron will contain as much as 5 per cent of titanium. The invention can be practiced by incorporating into any approved furnace charge, comprising titaniferous iron ore, fuel and fluxes, oxide of manganese in the form of manganiferous iron ore, so that nascent manganese will be present during the reduction. The titaniferous iron ore should contain at least 3 per cent titanic oxide, and manganese should be present in quantity not less than equal to 10 per cent of the titanic oxide. (1,104,317, July 21, 1914.)

**Ore Reduction.**—A novel proposal for the reduction of iron and other ores that are not volatile at a temperature of 800 deg. C., is contained in a patent granted to **Buenaventura Junquera**, of Oviedo, Spain. In brief, it is proposed to fine-grind the ore, fluxes and carbon for reduction, and feed the mixture at one end of a rotary furnace. The furnace is fired from the opposite end with pulverized fuel. The reduction of the pulverized mineral in contact with the reducing carbon is very rapid and occurs in the front end of the furnace at a temperature of 600 to 800 deg. C. When the mixture of reduced metal and flux reaches the high-temperature zone of the furnace (1500 to 1600 deg.) fusion occurs and the slag and metal are discharged into a receiver. The inventor claims that by his process iron ore can be converted in twenty minutes into molten iron containing 0.10 per cent carbon. The consumption of fuel for converting ore of 50 per cent iron into metal is about 1000 kg per ton of metal obtained, of which about 600 kilos is used for reduction and 400 for combustion. (1,102,339, July 7, 1914.)

**Preparation of Flue-Dust and Fine Ore for Smelting.**—In order to agglomerate fine ore and flue-dust and make a product suitable for charging into a blast furnace, Mr. **William Cooper**, of Denver, Col., proposes to inject into piles of such material a liquid hardening medium, such as a thin solution of cement. The grout thus formed is allowed to harden, after which the pile is broken into lumps. The binding material is forced into the pile through perforated pipes driven to the bottom. (1,103,400, July 14, 1914.)

### Gold and Silver

**Preparation of Refractory Ore for Cyaniding.**—The wet desulphurizing process used at the Nipissing mill, Cobalt, Ontario, whereby the refractory silver sulphide, sulpharsenide and sulphantimonide minerals are decomposed and rendered amenable to cyanidation, depends in principle on contact of the pulverized ore with aluminium in alkaline solution. A description of the work at Nipissing appears elsewhere in this issue. In a patent recently granted to Mr. **Charles Butters**, the process is outlined as follows: "The invention is based on a reaction which it has been found occurs when sulphide gold and silver ores, tellurides, and similar ores associated with, or not associated with, arsenic, antimony and the like are brought into intimate contact, such as by agitation or otherwise with certain metals such for example as aluminium, zinc, tin or palladium, in any convenient form, but preferably as metallic surfaces, in the presence of caustic soda or other caustic alkalies, either hot or cold, which results in such ores being decomposed and the metallic gold and silver being freed from combination with the sulphur or the like, whereby they are in condition to be readily attacked or dissolved by potassium cyanide or other suitable solvents. * * * Under these conditions an electric current is set up between the aluminium and the ore under treatment, the aluminium acting as the anode and the ore as the cathode, which latter, probably principally through the agency of nascent hydrogen, is then split up into its component parts, and the precious metals left free to be acted on by cyanide or other suitable solvents." Equations showing the effect on argentite are as follows:

$$2Al + 2NaOH + 2H_2O = Na_2Al_2O_4 + 6H$$

$$6H + 3Ag_2S + 6NaOH = 3Na_2S + 6H_2O + 6Ag$$

For gold telluride, the equation is:

$$AuTe_2 + 2Al + 4NaOH = Na_2Al_2O_4 + Na_2Te + 2H_2Te + Au$$

It is gathered from the patent specifications that the process is of wider application than that now known to be used at Nipissing. (1,103,346, July 14, 1914.)

**Chlorination of Ores.**—Frequent references have been made of late in technical literature[1] to processes for chloridizing low-grade ores containing gold, silver, copper and lead, according to methods devised by **N. C. Christensen, Jr.**, and **T. P. Holt**, of Salt Lake City, Utah, and to the mills utilizing such processes. In a patent recently granted to these men (Christensen assigning his interest to George H. Dern, of Salt Lake City) they disclose details of operation and furnace construction, practically as used at Park City, Utah, by the Mines Operating Co., under the direction of Messrs. Dern & Holt.

The preparation of the ore is accomplished by grinding, mixing with about 2 per cent of fuel, unless the ore contains fuel such as sulphides, mixing also with salt, and finally adding moisture varying from 5 per cent for coarse, non-absorbent ore, to 15 per cent for fine, absorbent material. The mixture is then roasted in a shaft furnace, such as illustrated in Fig. 1, in which air is forced through the charge from beneath, and in which certain zones are maintained as indicated in the figure. In this manner a counter-current flow of ore-mixture and air is achieved. The roasted ore is withdrawn from the bottom of the furnace and fresh mixture added from above. The roasting zone is always within the furnace charge and protected by roasted ore below and unroasted mixture above. The roasted ore is lixiviated with acidified water and the metal is precipitated from the solution as explained in previous articles to which reference has been made.

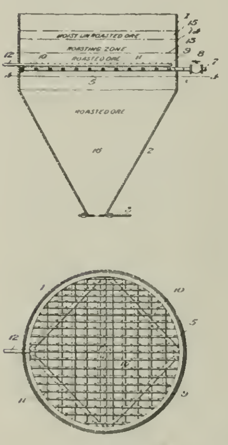


FIG. 1 — FURNACE FOR CHLORIDIZING-ROASTING

The furnace shown in the figure consists of a circular or square upper part 1 and a conical or pyramidal lower portion 2. The air-blast pipe 5 is disposed about the upper portion and connected with cross pipes, all having openings on their lower sides. A stirring grate 9 is placed just above the air pipes, and by its operation the roasted ore is gradually removed from the roasting zone and discharged through the gate 3 at the bottom. In starting the furnace, it is filled with roasted ore up to the level 13. A layer of live coals is then prepared and on this is charged the green mixture; the blast is applied, and the operations of discharging roasted ore and charging green ore proceed as desired. Gases from the furnace are dustless and are conducted to absorption towers to produce liquor for lixiviation. (1,107,240, Aug. 11, 1914.)

**Slime Filter.**—A new method of applying vacuum filtration to ore slime is disclosed in a patent granted to Mr. **Walter E. Trent**, of Reno, Nevada. As shown in Fig. 2 the filter consists of two wheel frames mounted on a shaft, with swinging filter pans or trays disposed between the spokes of the wheels, after the manner of a "Ferris" wheel. Each filter pan is connected with a source of vacuum through the pipe frames that constitute the spokes of the wheel which, in turn, communicate with the hollow central shaft. Feed is delivered to the filter pans through pipes that revolve with the frame and connect with an annular launder at one end of the shaft. Washes of water and solution can be applied as desired, and the filtered cake is discharged by automatically tipping the pans as they approach the point of discharge. As each pan is weighted, it resumes its horizontal position after dumping, when it is ready to receive a new charge. (1,097,896, May 26, 1914.)

---

[1] This journal, Nov., 1913, pp. 605 and 657, Apr., 1914, p. 222 July, 1914, p. 431 Aug., 1914, p. 492. Also *Bulletin* A I M E., July, 1914, p. 1699

**Another form of vacuum slime filter** on which a patent has been granted to **George Ridgway**, of Kalgoorlie, Western Australia, consists of two tanks to hold the slime pulp and wash solution, filter frames through which the slime is filtered, and rocking arms the transfer the frames from one tank to the other after the successive functions of filtering and washing have been performed. During the passage back from the wash tank to the slime tank compressed air is admitted to the filter leaves and the slime cake is discharged. Automatic reversing gear and valve trips govern the operation of the filter. (1,103,080, July 14, 1914.)

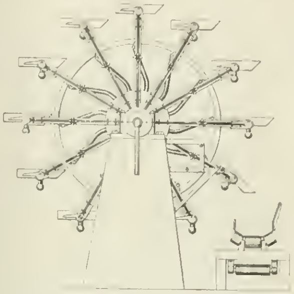


FIG. 2—VACUUM FILTER

### Lead and Copper

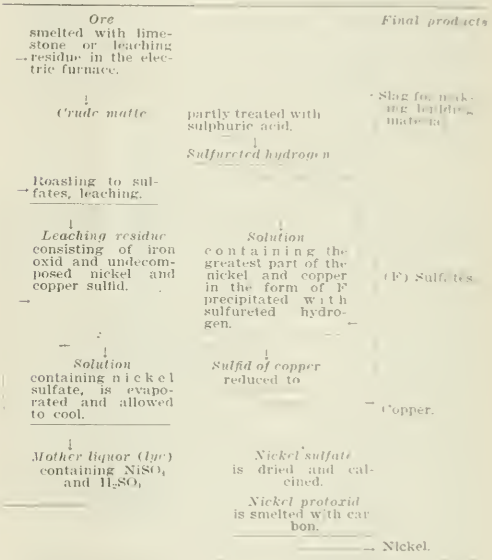
**Refining and Desilverizing Lead Bullion.**—An improved method of arranging and operating a plant for refining and desilverizing lead bullion by the Pattinson process has been patented by **William Thum**, of Hammond, Ind. According to this process, lead bullion containing silver is agitated with air or steam, and intermittently sprayed with water, with the effect of crystallizing the lead and leaving a liquid enriched portion containing the silver. The lead settles to the bottom of the kettle, while then enriched bullion floats above, as well as permeating the mass of lead crystals. The two portions are then separated, each being transferred in opposite directions through a series of kettles. The resulting desilverized bullion is cast for sale and the enriched portion for refining by electrolysis or cupellation or other form of refining. The transfer of the respective portions has hitherto been accomplished by raising the kettle being tapped, or lowering the receiving kettle, or by means of large ladles handled by cranes.

The present invention makes use of air pressure for the transfer of the products through the series of kettles, thus avoiding movement of the kettles and permitting a fixed arrangement. The kettles are constructed so that they can be removed from their settings in case of renewal or repair. (1,106,480, Aug. 11, 1914.)

**Reducing Cuprous Chloride.**—A patent has been granted to **Frederick Laist**, of Anaconda, Mont., for an improved method of reducing cuprous chloride in such a way as to regenerate the chlorine as a chloride salt suitable for reuse in chloridizing oxidized copper solutions. The method has relation to Mr. Laist's previously patented modification of the Hunt & Douglas method of leaching copper ores with sulphuric acid solution, containing also sufficient chlorine, in the form of a soluble chloride, to form the subchloride with the copper. Having dissolved the copper from an ore with the solution above mentioned, cuprous chloride is precipitated by treatment with sulphur dioxide. According to the present invention, in order to regenerate the chlorine therein contained for use on further lots of ore, the cuprous chloride is reduced with carbonate of calcium or sodium and carbon, whereby copper is reduced and the chlorine is combined with calcium or sodium. The latter can then be used to chloridize new oxidized solutions of copper. Mr. Laist's original patent is 903,732, Nov. 10, 1908 and was referred to in this journal Dec., 1908, page 510. (1,104,907, July 28, 1914.)

### Copper, Nickel and Zinc

**Treatment of Copper-Nickel Ores.**—In our issue for January, 1913, page 55, we presented an abstract of a patented process for the recovery of copper and nickel from low-grade ores and products, the inventors being Professor **Wilhelm Borchers**, of Aachen, Germany, and **Harold Pedersen**, of Trondhjem, Norway. It has now been discovered by the inventors that their process can be simplified in its latter stages, and they have secured an additional patent. Following is a synopsis of the improved process.



Ore smelted with limestone or leaching residue in the electric furnace.
Final products
Crude matte
partly treated with sulphuric acid.
Slag for making building material
Sulfureted hydrogen
Roasting to sulfates, leaching.
Leaching residue consisting of iron oxid and undecomposed nickel and copper sulfid.
Solution containing the greatest part of the nickel and copper in the form of F precipitated with sulfureted hydrogen.
(F) Sulfates
Solution containing nickel sulfate, is evaporated and allowed to cool.
Sulfid of copper reduced to
Copper.
Mother liquor (lye) containing NiSO4 and H2SO4
Nickel sulfate is dried and calcined.
Nickel protoxid is smelted with carbon.
Nickel.

The earlier patent is No. 1,043,291, Nov. 5, 1912; the current patent is 1,101,115, June 23, 1914.

**Separation of Zinc Blende and Barytes.**—The difficulty attending the mechanical separation of blende and barytes by ordinary methods of concentration are well known. According to specifications of a patent granted to Mr. **Charles J. Greenstreet**, of Webster Groves, Mo., a separation of these minerals can be effected by mixing them with a salt such as the chloride, sulphate or bisulphate of sodium and fusing the mixture. Under these conditions the barytes is mechanically combined and held in suspension with the molten sodium salt, while the blende is unaffected. The mixture eventually separates into two layers with the salt and barytes on top, and a separation can be made. On dissolving the salt, barytes is again precipitated. (13,735, Reissued May 26, 1914.)

### Rare Metals

**Vanadium.**—Two patents granted to **Harold Boericke**, of Vanadium, Colo., disclose the inventor's modification of the usual manner of treating vanadium ores by roasting with sodium chloride to form soluble sodium vanadate. The objections to the usual procedure are the high temperature required for the reaction and the consequent high fuel consumption. Mr. Boericke states that he has found that by the addition of a sulphide or a sulphate to the mixture the reaction takes place at a much lower temperature, with consequent reduction in the fuel consumption, and without material effect on the production of soluble vanadates. Thus 1 per cent iron sulphate added to the mixture has effected a saving of 50 per cent of fuel and has increased the capacity of the furnace 100 per cent. In case iron sulphide is added, it is first converted to sulphate during the reaction, after which it gives the same effect as though the sulphate were added originally. (1,105,-244-5, July 28, 1914.)

**Pyrophoric Alloy.**—Mr. **Paul Faehr**, of the Elektrochemische Werke, Bitterfeld, Germany, patents "a metal alloy containing a metal of the rare earth group and one or more of the metals zinc, cadmirum, tin or lead in such proportions as to make the alloy pyrophoric" (claim 1). Examples are 40 per cent. cadmium and 60 cerium; 30 zinc and 70 cerium; 30 tin and 70 ncerium; 30 lead and 70 cerium; 10 zinc, 10 tin, 10 lead, 70 cerium. These alloys not only keep for an indefinite time when exposed to air, but also in the presence of moisture, neither are they affected by great changes of temperature, nor by being placed in water. (1,102,575, July 7, 1914.)

### Metallurgical Furnaces

**Sinter-Roasting Furnaces.**—In the type of sinter-roasting machines devised by Dwight & Lloyd, the material to be sintered is deposited from a stationary hopper onto a moving grate that passes over a wind box. Ignition of the charge is started by a stationary source of heat and continued to completion by a downdraft of air. In a patent granted to Mr. **Francis D. Weeks**, and assigned by him to the Dwight & Lloyd Sintering Co., of New York City, the above order of operations is reversed, in that the grate and the charge of sintering ore are stationary, while the feed hopper, igniter and means for removing the sintered charge travel over the grate. The idea may be applied to either annular or straight-line machines. The advantages claimed for this modification of the process are that the charge of material on the grate is not disturbed in any manner, and less tax is placed on the machine in moving the weight of ore and grate. (13,758, Reissued June 23, 1914.)

**An improvement in pot-roasting methods** is patented by **Josef Savelsberg**, of Papenburg-on-the-Ems, Germany, whereby the usual formation of a layer of fine material at the top of the charge is prevented. Steam is added to the air blown through the charge, in sufficient quantity to condense in the upper cold layers, thereby moistening the mixture and preventing a separation of the material to be sintered from the parts of fuel. Part of the steam also is decomposed by the glowing fuel, forming water gas and promoting the sintering operation. (1,103,318, July 14, 1914.)

**Grates for pan-roasters** form the subject of a patent granted to **John E. Greenawalt**, of Denver, Colo. According to the improved construction the grate is made of interlocking sections, instead of one piece, and provision is made for expansion of the units when subjected to the heat of the sintering operation. (1,098,-035, May 26, 1914.)

**Another improvement in pan-roasters** patented by Mr. **Greenawalt** consists in constructing the furnace in two sections, the lower one being the hearth and the upper the ignition chamber. These are made separable, and the upper portion can be transferred from one lower portion to another, thereby serving for the ignition of a number of charges on as many hearths. (1,103,196, July 14, 1914.)

**Electric heating of the air supplied to roasting furnaces**, such as the superposed hearth type, is disclosed in a patent granted to **Utley Wedge**, of Ardmore, Pa. It sometimes happens that air is not sufficiently heated by passage through the chambers provided between the hearths, and in order to supplement such heat the inventor proposes to construct electric heating chambers in the outer walls of the furnace, wherein resistance coils will insure the heating of the air to the proper temperature. (1,086,494, Feb. 10, 1914.)

## Temperature Control for Industrial Purposes

Many chemical, metallurgical and industrial processes depend upon the careful maintenance of the temperature at a certain predetermined point. Thermostats are appliances which perform this function automatically. There are quite a number of thermostats on the market which are very successful for temperatures up to the boiling point of water. But the requirements of many industries call for an instrument which can be used quite as successfully for much higher temperatures.

In the following article we give a description of the Geissinger thermostat which can be adjusted to practically any temperature (being restricted only by the choice of materials of construction), and which is therefore applicable to the widest range of industrial processes. Before we enter into a description of this particular instrument, a few general remarks on thermostat design and on the classification of the different types of thermostats may be useful.

In most applications of heat in manufacturing processes the process has to be guarded against too high a temperature. For this reason Mr. Geissinger points out that valves which will close automatically when they are deprived of operative power give a higher guarantee of safety than automatic valves which are held open by a spring against air pressure upon a flexible diaphragm. While electricity supply is subject to rare interruptions, yet such may happen, and valves which will cut off the heating process in case of such failure follow the "safety-first" principle.

As to electric power versus compressed air or hydraulic power for the operation of valves, Mr. Geissinger points out that after all in general industrial practice electricity is proving to be most reliable and tractable force at the command of the engineer. While the electricity supply may fail in rare cases, yet Mr. Geissinger thinks an air-compressor has more reason to "lay down."

As to mechanical details of construction Mr. Geissinger lays particular stress upon the effect of heat and age upon diaphragm-operated valves. Should heat and constant flexure produce a crack in the diaphragm the valve would open suddenly.

Any properly working temperature-control apparatus breeds confidence and causes relaxation of attention. For this reason reliability on the "safety-first" principle, as explained above, is all important. Another requirement of any temperature control for industrial purposes is that it should "work close and keep working." If the investment of automatic temperature control is worth while at all in a heating process, the control cannot be too accurate.

We may now briefly discuss details of designs of various types of thermostats. They may be classed into two main groups: (I) Thermostats which operate valves directly, without any supplementary power and (II) thermostats which direct the operation of the valves with the aid of a supplementary power supply.

Group (I) may be subdivided into two classes. In (Ia) we have valves operated by the direct expansion of rods. The fact that the expansion coefficient of the most expandable materials under 1 degree rise of temperature is small, and that this expansion must be sufficient to close and open the valve to its maximum requires that large dimensions be chosen for the expandable part, if close temperature control is desired.

As (Ib) may be classed those valves which are operated by the vapor tension of a liquid immersed in the material under control. The range of this type is limited by the boiling points of different fluids under reasonable pressure.

Group (II) in which a supplementary power supply is used and which comprises the majority of commercial instruments, may also be subdivided into two classes, according to whether (IIa) compressed air or water or (IIb) electricity is the auxiliary power supply.

(IIa) The instruments operated with compressed air (of a high coefficient of expansion) have expansion tubes of reasonable dimensions, called upon to open very small "leakage ports." This leakage operates a pneumatic relay, admitting air to close diaphragm-operated valves.

To the same class belongs the type making use of the vapor tensions of liquids in bulbs exposed to the material the temperature of which is to be controlled. Again, the motion of the diaphragm is limited to leakage control of the air supply to the diaphragm valve. The air ports are necessarily small and air-filters are an adjunct to these types of controllers, in order to prevent dust or oil (with which the air in manufacturing processes is often charged) from choking the fine air ports.

(IIb) In the electric thermostat class we find possibly both the oldest and latest forms of instruments.

We are all familiar with the compound bar made of plates of brass and steel riveted together. Such compound bar is fixed at one end and free to make contact on one or two points at the other end. The layers of metal must be made thin to produce a marked motion of the free end under changes of temperature. This same condition makes the whole structure a weak spring. This form of thermostat must be subject to several degrees change of temperature to create a small pressure between its contacts.

The effect of pressure on the contact resistance of two platinum contacts has been the subject of special investigation. Mr. Geissinger states he has found that an electric thermostat working under commercial conditions has to exert a pressure between the contacts of at least 0.01 lb. in order to close the circuit and that this pressure must probably be double with a trace of oil between the contacts.

Another modern type uses the vapor pressure of a volatile liquid, or the expansion of mercury in a bulb exposed to the material under control, operating the familiar pressure tubes of recording instruments, the index hand being equipped with one or two contact points. Mr. Geissinger states that "a mercury-filled temperature recorder-type thermostat with a pointer moving 0.3 in. for 10 degrees F. exerted a force of 0.02 lb. under restraint produced by a difference of 10 degrees F."

The sensitive portion of the Geissinger thermostat shown in the adjoining illustration consists of a metallic or vitreous tube with some coefficient of expansion, and an inner rod of an alloy of practically zero coefficient of expansion.

The tube is either cast integral with or welded to the head. The end of the tube is fused over.

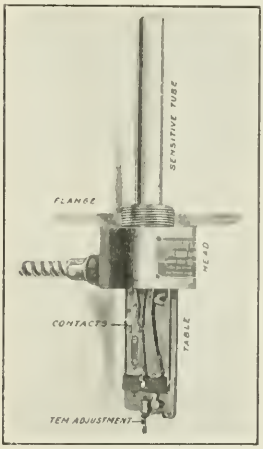
There is bolted to the head a part called the table, carrying the electrical parts of the instrument, the "contact" and the "contact arch." The inner end of the contact arch is operably connected to the non-expanding rod, while the outer end is held in a piece united to the inner end of the table by flexible side bars. The side bars and contact arch are of the same length, section, and material. They expand equally under any temperature the head may be.

The free end is capable of considerable lateral movement on the table, on account of the flexibility of the side bars. Such movement is produced by the temperature adjusting screw operating through an angle lever. Displacement of this free end alters the distance between the contacts. Each adjustment demands a different expansion length of the sensitive tube to produce contact and consequently another temperature in the surrounding medium.

The contact arch is a normally flat piece of spring steel, forced into a shallow arch by end pressure, or shortening of the chord. It is evident that the movement of the vertex of such an arch is a magnification of the shortening of the chord, the relative motion being a function of the length over the height of the vertex.

Again, imagine a non-compressible shallow arch set in an inelastic chord, loaded in the center. Such arch can be loaded without change of shape, until it "breaks" like masonry. In the action of the thermostat the vertex of the contact arch is brought against the contact point, and apart from the end thrust and compression of the parts, instantaneously a force is obtained which "breaks" the arch into a curve with three radii. The pressure between the contacts after the "break" is 0.6 of the breaking load.

Now for any size and material the breaking force is proportional to the height of the vertex, and the longitudinal stresses uniform in all heights of vertex. It should be borne in mind that we have to do with curves with relatively long radii.



ELECTRIC THERMOSTAT

The rigidity of the contact mechanism permits the use of sensitive tubes of a very low coefficient of expansion, covering a wide choice of compositions appropriate to the temperature and chemical nature of the material under control.

The maximum contact pressures are variously set between 0.75 and 2 lbs. No matter how great the difference between the working and atmospheric temperature, the contact pressure when cold is 60% of the maximum. The compressive stresses are negligible, there is no "set" to the tube. If an instrument cools off once a week it keeps clean of oxide. If in fact anything interfered with the passage of the current between the contacts, it is at once crushed by a force that amounts to 0.9 lb. per deg. F. below the standard temperature. This comparatively very high force ensures the reliable working of the instrument.

The Geissinger thermostat is made by the Geissinger Regulator Company, 203 Greenwich Street, New York.

**Borax.**—In 1913 the production of crude borate materials in the United States was 58,051 short tons valued at $1,491,530, according to the U. S. Geol. Survey.

# Repairing a Crank Shaft by Autogenous Welding

BY C. H. BURROWS

A chief engineer is frequently required to use unerring judgment in making extensive repairs in his power plant, and to make these repairs permanently durable and neat in appearance in a quick and economical way. An occasion which requires such ability comes unexpectedly and is usually attended by a complete shutdown of his plant. To keep himself forearmed for these emergencies, it is desirable to know of the methods and success other mechanics have had under such circumstances; and with a motive to contribute to his preparedness, I call attention to the prompt results and unusual success obtained in repairing a large crank shaft by autogenous welding with an oxy-acetylene torch.

The crank shaft was 6 in. in diameter by 11 ft. long, and was a member in a three-cylinder 100-hp producer-gas engine belonging to a single-unit electric-lighting plant.

It was broken square off through one of the arms and totally disabled the entire plant.

Just previous to the welding operation, the fractured ends were placed in a glowing bed of charcoal, and surrounded by brick to thoroughly preheat the portion adjacent to the fracture. This performance was not vital to the actual welding operation, but was only an economic measure to save gas. After preheating it was perfectly aligned on V blocks and with the torch a gap was cut on opposite sides. The sloping sides of the gap forming an angle of about 75 deg. with the vortex at the point of fracture, in the center of the shaft. This cutting was done entirely with the torch and left the sides of the gap dripping with molten metal, which condition penetrated the material of the shaft. In fact, it would be exceedingly difficult to determine just where this molten condition actually terminated. This fluid and semi-fluid state was maintained or renewed with the torch while the gap was being welded full of molten steel from the welding rod, working from the center of the shaft outward.

The weld was then finished by eventually melting away the superfluous metal and smoothing off with the torch. The apparatus and the torch used were those furnished by the Vulcan Process Company, of Minneapolis.

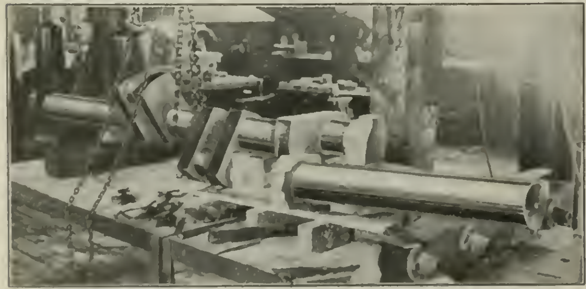


FIG. 1—CRANK SHAFT BROKEN

The complete job was welded and ready to deliver in less than twenty-four hours at a cost of about $26 as

| | |
|---|---|
| 8 hours welding time at 35c | $2.80 |
| 812 cu. ft. oxygen gas | 16.24 |
| 817 cu. ft. acetylene gas | 6.54 |
| 50 lb. charcoal at 1c | .50 |
| | $26.08 |

After cooling the weld was found to be perfectly homogeneous in texture, void of fire-scale or oxidation, and machined freely.

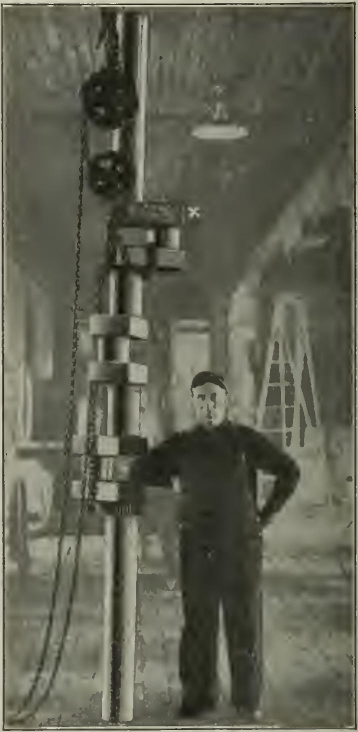


FIG. 2—CRANK SHAFT WELDED

This crank shaft has now been in heavy service for several months and given perfect satisfaction.

Minneapolis, Minn.

---

## Recording Gas Calorimeter

Primarily for use in gas power installations the Lexington Instrument Works, of Lexington, Ohio, has developed the Smith recording gas calorimeter which is perfectly automatic in giving the heat value of a gas (for instance, producer gas) per cubic meter. The record of the instrument is automatically corrected to the accepted standard of gas at 60 deg. Fahr. and 30 in. barometer. The readings are also practically independent of atmospheric conditions.

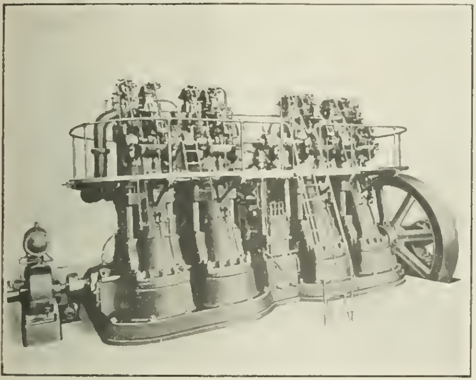
The equipment consists essentially of two parts, namely, the sampling pump and the calorimeter. The sampling pump is a small power-driven metering apparatus, which delivers continuously a measured and proportionate amount of gas and of ordinary atmospheric air. The gas and air are delivered from the sampling pump through separate pipes to the calorimeter, where the gas is burned in and with the air and the rise in temperature of the air recorded as a measure of the heat value of the gas.

The instrument is designed primarily for use in gas-power installations, to control the effectiveness of the gas for operation of the gas engine and also to control the efficient working of the gas producer. It may also be employed to advantage where gas is to be used for metallurgical purposes requiring fine temperature adjustments.

## Large Oil Engine

The largest Diesel engine ever constructed in America will be the first piece of heavy machinery of this type taken through the Panama Canal.

The engine is composed of four huge cylinders and is capable of developing 690 horse-power. It was constructed in the immense plant of the Lyons Atlas Company of Indianapolis and has been sold to the Hawaiian Commercial & Sugar Company to be used for irrigation purposes in the Hawaiian Islands where it will operate pumps of 15,000,000-gal. capacity.



LYONS-ATLAS DIESEL ENGINE FOUR-CYLINDER, 600-660 BHP ENGINE WITH DIRECT-CURRENT-CONNECTED AIR COMPRESSOR

The big Diesel engine left the Indianapolis factory last month for Hawaii via the Panama Canal.

The conditions covering the acceptance of the engine were severe. The purchaser insisted that the engine should operate continuously 710 hours out of each 720 hours per month at rated load, using the ordinary 14° to 18° asphaltum base California fuel oil, similar to that used in the purchaser's steam plant, and which is the only grade available on the Islands.

The test was conducted by the chief engineer of the H. C. & S. Co., and the engine was given a preliminary continuous run of forty-eight hours with Eastern parafine base fuel, after which all parts connected with the combustion chambers were inspected in order to determine a basis for comparison between the effect of the two fuels. It was then subjected to a 144-hour continuous run at full load with fuel shipped by the purchaser from California to the manufacturer's works. At the completion of this run the combustion chambers were again examined, and as there was no evidence of deposit on the heads, valves or pistons, the engine was accepted and is now en route to the Island, to be erected by their own engineers.

---

The **Fuller-Lehigh Pulverizer Mill** is the fifth of a well-illustrated pamphlet, issued by the Lehigh Car, Wheel & Axle Works, of Fullerton, Pa. It is particularly interesting on account of descriptions of equipment used for the production of pulverized coal suitable for heating industrial furnaces.

## American Manufacturers and the European War

In reply to a request for an expression of opinion a to the effect of the war on metallurgical and chemical activity and on business in general, *Metallurgical and Chemical Engineering* has received numerous statements from American manufacturers.

Manufacturers of machinery for the non-ferrous metallurgical field refer to the cutting in half of the activity in copper smelters and refineries. One prominent manufacturer writes: "The effect of the war on our business has been that copper inquiries have stopped. One of our best orders has been canceled, and another was attempted to be canceled, but was already shipped."

Among the replies from steel manufacturers the following is typical: "We import from Europe ferromanganese and magnesite, but no alarming shortage of these materials has developed so far and we think the steel manufacturers will be able to secure all they will require, although probably at somewhat higher prices. This, of course, will have the effect of increasing the cost of steel making.

"The effect of the European war on our own business has been to curtail it and we look for somewhat decreased operations during the remainder of the year. This has been brought about by the inability to finance new enterprises, new buildings and the railroads. Spelter, of which we are large users, has advanced in price, owing to the alleged large demand from England, which, however, has only materialized in comparatively small tonnages. Spelter is in abundant supply in this country and will probably reach a normal price level within a few weeks."

Another manufacturer writes: "In the event of the supply of ferromanganese either being exhausted or the price becoming very high, ferrotitanium would undoubtedly be substituted therefor to a considerable extent so far as ferromanganese as a deoxidizer is concerned. In some instances, where titanium is being used, manufacturers have cut down to a certain extent the amount of manganese in their steel, although it is not wise to recommend such a change at this time."

The *Noble Electric Steel Company*, of San Francisco, Cal., states that anticipating the present conditions it has recently been preparing to manufacture ferromanganese at its electric smelter at Heroult on the Pit, and within the next ten days one furnace will be blown in, with the possibility of a second furnace being blown in a few days later. In California there are a great many manganese deposits, several of which are of considerable extent and of good grade, but inability to meet foreign transportation costs has caused these properties to remain idle. Now the Noble Electric Steel Company can enter the field of making ferroalloys of manganese and chromium. It will not be slow to take advantage of the opportunity the European war has created. The furnaces at Heroult are admirably adapted for the purpose, as metallurgical details for making ferromanganese are quite similar to those in making pig iron. The Noble Electric Steel Company expect to get a market for its ferromanganese not only in the steel works on the Pacific Coast, but also in Japan.

Mr. Wm. C. Cuntz, general manager and treasurer of the *Goldschmidt Thermit Company*, of New York City, says: "I do not see that our business will be affected by the war, other than in the general effect the war will have on all business. We are in position to manufacture practically all our material here and while certain raw materials are difficult to get and high priced at the present time, I am inclined to think that this situation will soon straighten out, provided some way is found of putting the business of the country in the hands of business men rather than those of politicians, and provided also that economy is practised by these same politicians and everyone generally. By economy I mean not only in personal matters, but in the treatment of resources."

A prominent manufacturer of platinum ware states that "so far the effect of the European war has been to increase the cost by from 10 to 15 per cent, this being in part largely due to the increase in cost of transportation, insurance, war risk and exchange. For the present we have sufficient stock in hand to meet our customers' reasonable requirements, and as to the future a great deal would depend upon the duration of this trouble, for, as is probably well known, Russia is the chief source of supply. As to a substitute, the peculiar and noble qualities of platinum preclude the possibility of using a substitute in a great many instances or uses, and in this connection we might state that in some lines where they have attempted to use a substitute they have been forced to return to platinum. As yet we are unable to say anything definite as to the possibilities of South American trade."

Among electrochemical manufacturers, Mr. W. Acheson Smith, general manager of the *International Acheson Graphite Company,* states that its "supply of raw materials has not been interfered with in the least, and we are prepared to supply Acheson graphite in any quantity."

An electric-furnace operator states that the only supply he has been obtaining from Europe has been large carbon electrodes. "As these are now also made in this country we do not feel that the European war will affect us seriously in any way in manufacturing."

Mr. C. L. Allen, general manager of the *Norton Company,* Worcester, Mass., states: "We are not dependent upon European raw materials. We have received from time to time a few raw materials from Europe, but have never been dependent upon them. Whatever we require is available in this country. We are not looking for substitutes. As more or less abrasives have been imported it is possible that we may be able to supply some of our own in place of these. So far as our line is concerned the effect on export business ought to be favorable, but not now to a great extent because the demand for our goods is not fully developed."

Mr. Geo. E. Long, vice-president of the *Joseph Dixon Crucible Company,* states: "We have been dependent on Germany for clay for crucible making and for the clay which enters into pencil making. We would gladly have used an American clay if one could have been found suitable. So far none has been found. It is not a question of price but of material only. The Dixon company has also been obliged to look to Germany for its best quality of mineral colors and aniline colors. We are looking now, as we always have been, for these materials in our own country, and there are no substitutes so far that we have been able to find."

Activity in certain chemical fields is indicated in various replies from manufacturers of chemical apparatus and machinery, although several of them do not wish to be quoted for publication.

Messrs. *L. O. Koren & Brother,* of New York City, write as follows: "Very soon after hostilities commenced between the nations at war in Europe we received inquiries from a number of both large and small producers of chemicals for special apparatus, same to be used in the manufacturing of chemicals which until now, we understood, were manufactured abroad. In some instances chemicals, for which we have orders for special apparatus, were being manufactured here in some quantities, but as the foreign supply has been lessened it will be necessary to increase the output for such chemicals here very materially. In some cases chemicals which were not manufactured in the United States in the past are now, so we are advised, being made here. As a result of the increased production of chemicals in the United States we have received orders in the past few weeks for apparatus which we believe would not have been ordered of us had the conditions in Europe not changed. Some of the apparatus which we are making are duplications of what we made heretofore. We also contemplate the building of apparatus which will be duplicates of things now used abroad. . . . We believe that the manufacture of any chemical products which are once manufactured in this country will be continued. This has been the case in the metal lines. After the factories are once provided with the necessary equipment and the men familiar with the methods of manufacture, there is no reason why chemicals once manufactured here should not be made in competition with foreign goods."

Mr. F. J. Stokes, of the *F. J. Stokes Machine Company,* Philadelphia, states that his company is in nowise dependent on Europe for materials, but as its sales are mainly to the manufacturers of chemicals and pharmaceutical preparations, who have been seriously affected, sales have been slightly influenced. "Pharmaceutical manufacturers have been enjoying a sudden rush of business, which seems to be regarded by them as only temporary and, therefore, they will not purchase additional equipment. The same applies to the manufacturers of chemicals, although there is a disposition on their part to take up the manufacture of the products heretofore imported. The installation of new apparatus of this kind requires careful consideration and the increase of sales from this source will not be immediate.

"In reference to exports to South America, there has been an increase in requests for quotations. South Americans, however, are slow buyers, especially in apparatus of a technical nature, and considerable correspondence has to be entered into before they will place an order. We do not, therefore, look for much increase from them under two to four months."

Mr. F. M. de Beers, general manager of the *Swenson Evaporator Company,* of Chicago, Ill., believes that "the final result of the war, so far as American manufacture is concerned, is bound to be beneficial and that it will open up new fields of endeavor. So far as our particular business is concerned it will help us by eliminating some price competition in foreign countries, which resulted in so much of the business going to European manufacturers. As regards the purchasing of evaporators to be used in the United States, or in our neighboring countries, the war can hardly affect this one way or the other, as the best machines are built here, and the American purchaser knows enough to disregard a possible lower price of a foreign competitor. There is no immediate effect upon our costs, as most of our raw materials are produced here, but the financial condition is such that most new and large developments in the chemical industry are being postponed or abandoned."

Mr. R. L. Cawood, manager of the *Patterson Foundry & Machine Company,* of East Liverpool, Ohio, states that "we have hardly had sufficient time in which to judge what European conditions will do for America or what effect their troubles are going to have on our industrial condition. Theoretically, at least, their misfortune should be our opportunity. This should improve our export business to South America, as this country is now the logical source of supply for that territory and a great many of our products should find a ready market there.

"So far as importations of material into this country are concerned, I believe that this will temporarily work a hardship on a few manufacturers who are importing materials that are not at present made in this country. This handicap will gradually disappear as substitutes for these materials will undoubtedly be found in this country and similar materials manufactured here. This will mean increased industrial activity throughout this country. Goods like pottery, toys and other articles which are imported very extensively and which are no better than similar articles made in this country, will be made here in place of being imported. Two-fifths, or in other words 40 per cent, of our china and earthenware is imported. It is no better than the home product, but is made with cheaper labor abroad. The importation of these goods being shut off will undoubtedly help our own manufacturers.

"The stocks of imported goods in this country at the time of the European outburst were sufficiently large to tide over a great many consumers until the present time. Consequently we have not as yet felt the real effects of the changed conditions. In my opinion it will be sixty days more before we do so."

Another Middle Western manufacturer of machinery for chemical and allied industries, who wants to remain unnamed, says that "so far the effect of the war upon our business has seemed to be a quite general deferment of anticipated requirements. Our opinion is that the cutting off of certain supplies from Europe will result in a slow-up until other sources of supply or substitutes can be obtained or peace permits a resumption of deliveries. We believe the effect upon export business will be a curtailment until the war closes. It will take much time, careful, direct investigation and adjustment to ways and means that are not attractive but can, no doubt, be harmonized to mutual advantage if both interests pursue the policy of give and take."

The vice-president of a prominent Eastern manufacturing company, desiring to remain anonymous, writes: "A very large proportion of our business is with the railroads and while they are, as we all know, suffering from lack of supplies and equipment, they are not buying anything that they can possibly do without; nor do we see how they will be in a position to buy normally until there is some financial readjustment effected that will enable them to borrow money freely.

"We do considerable business with some of the larger industrial plants, one or two of which have held up a great many orders owing to the general financial situation. As far as we can see, this is more a measure of precaution than of necessity, however.

"We do not feel that the export business to South America will be of such a volume as is popularly supposed until this country is in a position to help them finance their operations. It is our observation that most of the South American countries are at present in financial straits, owing entirely to the European war and the manufacturers in this country are in no position at the present time to grant the long credits that have been customary with the English and German manufacturers on South American business.

"We believe that the railroads will eventually secure their 5 per cent increase and that the financial situation will slowly adjust itself to the new conditions, and that shortly after the first of the year business in general will return to a more normal basis.

"We feel, however, that it is going to be some time before the American manufacturers and foreign buyers can so rearrange their methods of buying and selling that any greatly increased export business will result. However, we feel that this business is bound to come in time, and that when the South American countries are once educated to the purchase of goods from this country that Europe will never recover the business."

The *American Vulcanized Fiber Co.*, of Wilmington, Del., makes the following statement:

"The raw materials from which vulcanized fiber is made, viz., cotton cellulose, coloring matter and zinc chloride, are all imported into this country in very large quantities. The European war has, of course, stopped the importation of these commodities, with the result that the cost of all our raw materials is steadily increasing. Unfortunately, no substitution can be made without more or less seriously impairing the quality of the finished product.

"For instance, cotton cellulose in the form of rags costs now $10 to $20 per ton more than a month ago. We have our own mill which separates directly from the cotton hulls a very pure cellulose which we use largely for certain grades of vulcanized fiber, but we also use large amounts of cotton cellulose in the form of rags, the price of which in this country is regulated by the European supply.

"It is at present almost impossible to get aniline colors, and manufacturers of fiber in common with many others will be forced to depend entirely upon mineral pigments, with the inevitable result that the price of these will be forced up. Certain colors will probably have to be discontinued after the supply of coloring matter now on hand runs out.

"The price of zinc chloride and even the available supply is likely to be seriously affected by the war, as is seen by the fact that large quantities were imported from England and Germany in 1913. We ourselves are somewhat more fortunate than most, because we have an independent source of supply for zinc chloride which will not be affected by European conditions. In this connection we are glad to state we shall have during the next twelve months an excess of this chemical, which we can deliver in our own tank cars as a C.P. or commercial solution of any desired strength. We also have our own supply of pure red oxide pigment, and expect to be able to offer some of this for sale.

"The immediate effect of the war is to reduce very materially domestic sales of our finished product. In our opinion the ultimate effect of the present war may be to stimulate the export business with countries other than Europe, but it is not to be expected that this will make up for the loss of the European trade, for industries in those countries have not developed along lines that require vulcanized fiber in the large quantities that are used abroad, and we are, of course, in general adjusting our organization to meet the changed conditions."

Mr. F. R. Still, secretary of the *American Blower Company*, of Detroit, Mich., thinks that in spite of some discouraging indications "there is every reason for believing that business should be good, and it will it everybody will keep cool and proceed cautiously and steadily. It will take some time to adjust finances to the changed conditions and still longer before business gets up the momentum to meet the coming demand, during which period expenses and credits must be watched carefully. 'Necessity is the mother of invention'; this war will be an incentive to find substitutes for many materials we all have been accustomed to use, or to induce capital to invest in the production of old material heretofore produced in Europe almost exclusively. The final result will probably be much the same as was the building up of the tin plate industry under the McKinley tariff; when capital was offered the inducement it went into it and soon got onto a footing that almost excluded foreign competition.

"Our company has been dependent on the European countries for raw material only in a limited degree, such as tin, manganese, plumbago, etc.

"South America is reported to us to be in a bad way financially and business is almost at a standstill. If our Southern neighbors can place large loans in this country, and branch banks be established down there and capable representatives be sent to canvass their wants, and goods be made to suit their demands, then a big business should ultimately be the fruits of such efforts, but this is a long time away and with characteristic American impulsiveness, many are likely to become discouraged in their efforts before the successful conclusion of such a campaign is reached. If the war lasts long enough to enable this country to get started in foreign fields, Europe can never overtake us in this or the next generation. But should it suddenly cease, in the near future, we will find ourselves just where we were before it started."

Mr. W. F. Graver, vice-president of the *Wm. Graver Tank Works*, of East Chicago, Ind., states that they "have been selling storage tanks to some of the refiners who export petroleum products to the European countries, and this business is necessarily curtailed until the existing conditions abroad are changed. On the other hand, the curtailment of petroleum shipments has increased the need for storage in this country and some of the larger companies are buying considerable tankage to take care of the production.

"As to the effect on export business, I would say that benefits must necessarily accrue as far as the steel line is concerned as the greater part of material in this line for South America, the Islands and Mexico are shipped from Germany. As far as our line is concerned, our experience would indicate that a large amount of export businss is lost annually through indifference and unfamiliarity with foreign requirements and conditions. We believe that, once established, our trade with South America will be permanent.

"We also believe that the existing conditions will convince the American manufacturer of the undesirability of being entirely dependent upon foreign countries for raw material and that they will not overlook the opportunity to develop industries which are now perfected abroad, and to draw on our vast resources for substitutes to replace foreign produced raw materials now unavailable. These changes must eventually come and the present state of affairs makes it imperative that the changes come now."

Mr. Irving C. Jennings, manager of the *Nash Engineering Company*, of South Norwalk, Conn., states that "business fell off somewhat with the start of the war, but is now picking up again."

Mr. *A. J. Weeks*, manufacturer, of Akron, Ohio, states that they have everything they need for manufacturing chemical stoneware in Ohio, so that they are affected by the war only as far as the general business is affected. "The tariff revision did hurt, as it placed foreign ware on less duties into this country. This war may help us somewhat in the near future, cutting off foreign importations. It will take time and facilities to get into exporting to South America. In the end I consider the war will not be of great benefit to this country as calamities usually spread and affect all the conditions of the world."

Mr. *Maurice A. Knight*, of East Akron, Ohio, states: "As Germany imported a good deal of acid-proof stoneware, we now expect to get our share of what was their business. Our ability and equipment to get out our product has not been affected in any way. I have had more inquiries from South America in the last six weeks than ever before."

Mr. F. E. Finch, of the *Ruggles-Coles Engineering Company*, of New York City, staes that they have had several orders canceled, especially for foreign shipments, due to the present war, but have also received inquiries and orders from companies and individuals who would usually go to France or Germany for their machinery. "We expect to increase export business to South America, and hope to place that on a firm foundation."

The manufacturer of a chemical commodity which is largely used in the electrical industries, writes: "The volume of our business would be almost entirely dependent upon the prosperity of the general electrical manufacturing industry of this country. How this is to be effected by the present European situation is more than the writer can vouchsafe to answer.

"We have not reduced or increased our organization recently, although our business continues to maintain itself in a very healthy condition. We have so far been almost entirely dependent upon Europe for certain supplies, but it is the writer's opinion that if the interruption to European manufacture and export continues for any length of time the coke producers of this country will desist from wasting their by-products."

The president of a company making special electrical machinery who likewise wishes to remain anonymous, states: "Up to the present time we have not been seriously inconvenienced by being cut off from European raw material. Very little of such materials have entered into our devices and we were fortunately well provided with such minor items as solder, etc., which do not enter in large quantities into the construction of our apparatus. Simultaneously with the outbreak of the war there was, and still continues to be, a marked increase in business, and we have traced a number of these orders to electrochemical and electrometallurgical organizations which will endeavor to supply materials which have formerly been coming from abroad. Our bulk of business on hand at the present time exceeds that which we had on hand a year ago. We do not look for any great increase in orders for special transformers from the South American trade, but will expect to profit indirectly from the business which the electrochemical and electrometallurgical industry of this country will undoubtedly secure."

Messrs. *Merck & Company*, of New York City, have issued an Emergency Price Guide for temporary service. One strong recommendation made in it is to use sodium salts instead of potassium salts wherever possible. "The sodium salts, of which there need be no more than a temporary lack, deserve to be more widely issued, and we would urge all our friends to use them in all cases where they have been in the habit of using the potassium salts, because of the constant source of supply."

Mr. Chester G. Fisher, vice-president and general manager of the *Scientific Materials Company*, of Pittsburgh, Pa., says: "A large portion of our chemical apparatus has been made in Europe. The principal reason for making many of these articles in Europe is not because they could not be made in this country, but because they could be made in Europe considerably cheaper. We are at present manufacturing many articles here in Pittsburgh which we have heretofore made abroad, but the cost of these articles is considerably greater than the same articles made in Europe. There are, of course, some articles which have been developed to a very high degree in Europe which would take a long time and considerable research work to equal were we to make them in this country, and on such articles we have no recourse but to wait until the European situation adjusts itself."

A pyrometer manufacturer who wants to remain anonymous states that he has been importing considerable raw material from Europe and when his supply runs out he expects some difficulty in obtaining them. The war has also affected his export business to Spain, Sweden and other countries.

Mr. C. H. Wilson, of the *Wilson-Maeulen Company*, of New York City, writes: "As most of our importations are from England, these have not been materially disturbed. There are some few things which we have obtained from the Continent which we can unquestionably replace from local sources. In this connection it seems that someone should point out to the American manufacturer that when someone comes to him to replace what that someone has been heretofore obtaining from Europe, the American manufacturer should take a keen interest in the prices and qualities of what has heretofore been imported, otherwise the American manufacturer can hardly be very sure that he will hold the trade when European business gets back somewhere near the normal. That is to say, even if he finds his customer willing to accept what he has to offer, he should bear in mind that that customer may be accepting it as a temporary shift and that this is the time when he should display such keen interest in the requirements of his customer and should expend such efforts to meet the requirements as will insure permanently holding the business."

## Personal

Mr. **Franklin Guiterman** spent the month of September at the Denver office of the American Smelting & Refining Co. Mr. **L. G. Eakins**, manager of the Colorado department of the company, was absent on vacation.

Mr. **Stuart S. Bruce** has resigned his position as professor of metallurgy at the Michigan College of Mines, and will be out of professional work for a time. At present he is at Victoria, B. C.

Mr. **W. J. Pentland**, manager of the Amajac Mines Co., has returned to Mexico and will make an effort to renew the work of constructing a cyanide mill. He will be at Hotel Cosmopolita, Guadalajara, Jalisco, for a time before going on to Hostotipaquillo.

Mr. **J. B. Tregloan**, superintendent of the McNamara mill, Tonopah, Nevada, has returned to his duties after an extended trip east.

Mr. **D. L. H. Forbes** has been appointed chief engineer of construction for the Chile Exploration Co., and has gone to Chuquicamata. He was formerly on the staff of the Merrill Metallurgical Co., and consulting engineer for the Trethewey mine at Cobalt.

Mr. **W. P. Lass**, superintendent of the cyanide plant of the Alaska-Treadwell Gold Mining Co., resigned his position, effective Sept. 1. He will open an office in Juneau with Mr. **E. P. Kennedy** and give attention to the development of the Speel river hydro-electric power project.

Mr. **Frederick Lyon**, vice-president in charge of operation for the U. S. Smelting, Refining and Mining Co., is making a tour of the company's plants in California, Arizona, Indiana and New Jersey.

Mr. **C. B. Lakenan** is reported to be recovering satisfactorily from an operation recently performed at the Mayo hospital.

Mr. **Andrew W. Newberry** visited Utah and Colorado mining districts following the Salt Lake meeting of the American Institute of Mining Engineers.

Mr. **William W. Clark** has resigned as chief chemist and metallurgist of the American Vanadium Company to accept a position as metallurgist with the Seymour Manufacturing Company, which will install a metallurgical laboratory.

Prof. **Joseph W. Richards**, of Lehigh University, has returned from Europe via Copenhagen. He was in Germany when the war started.

## Obituary

**James Porter Evans** died suddenly at his home, 1427 Franklin St., Denver, Col., on Sunday evening, September 13.

Born at Zanesville, Ohio, November 29, 1860, he came to Denver in 1881 and engaged in the railroad business. He continued in that field, rising through various positions to that of auditor of the Denver and Rio Grande Express, which connection he severed in 1895 to enter the Colorado Iron Works Co. of which he was vice-president and general manager at the time of his death.

His activities in connection with the development and manufacture of mining and smelting machinery brought him into intimate contact with many men of note, and in his sudden demise the mining industry loses a prominent figure.

Mr. Evans had drawn to himself a wide circle of friends who had become endeared to him through his upright character and genial disposition. Upon these his loss will fall as a personal bereavement. He had long suffered from asthma and the fortitude with which he bore up under repeated severe attacks of this ailment was a source of admiration by his intimate friends. Taken with pneumonia on Wednesday but few knew of his illness and none feared its fatal termination. He belonged to Oriental Lodge No. 87, A. F. & A. M., of which he was a charter member, Denver Commandery No. 25, Knights Templar, and of El Jebel Temple, A. A. O. N. M. S. He was also a member of the American Institute of Mining Engineers, the Denver Club and the Denver Country Club.

He is survived by his widow, Mrs. Isabel Nesmith Evans and one daughter, Elisebeth.

## Digest of Electrochemical U. S. Patents

PRIOR TO 1903

*Arranged according to subject-matter and in chronological order.*

*Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.*

AQUEOUS BATH (ELECTROPLATING) *Continued*

570,554, Nov. 3, 1896, Eduard Jordis, of Munich, Germany.

Relates to the art of electrodepositing metals or alloys, and also to scouring or cleaning by electrolysis, and consists in the employment of lactic acid or lactates in the bath. When employing pure solutions of the required metal lactate, such metals as nickel, iron, copper, and zinc are deposited and have a dark velvety color. By the addition to the electrolyte of alkaline lactate, and sulfates or other salts of more electropositive metals than the metal to be deposited, such as aluminium, magnesium, etc., the color of the deposited metal will be lighter, so that many shades of deposited metal may be contained, by adjusting the conditions of concentration, temperature, and current density. The conditions for electrodepositing several metals are given.

571,531, Nov. 17, 1896, Rudolf Langhans, of Berlin, Germany.

Relates to the electrolytic production of oxide coatings of the earth and alkaline earth metals. To a solution of a salt of an earth or alkaline earth metal is added the hydroxide of the same or different base, and dissolved therein with the aid of heat; the resulting solution is electrolyzed with insoluble electrodes, with high or low current density, a deposit of a hydrated oxide separates out and adheres more or less closely to the negative electrode according to the condition of the electrolyte and the circumstances of the electrolysis. The conditions are given for obtaining deposits of the hydrated oxides of zirconium, thorium, yttrium, aluminium, and magnesium; and for obtaining an oxide deposit upon a wire mesh incandescent gas-light mantle.

571,532, Nov. 17, 1896, Rudolf Langhans, of Berlin, Germany.

Relates to the electrolytic production of oxide coatings of the earth or alkaline-earth metals which will be porous and both cohesive and adhesive. Aqueous solutions of the water soluble or "meta" hydroxides of the earth or alkali-earth metals are well adapted for this use. A diluted solution is employed, containing about 3 per cent, for example, of the water-soluble hydroxide of thorium, and electrolyzed with a current of 0.03 amp per sq. cm. The deposit is a perfectly cohesive and adhesive layer of insoluble hydroxide, which may be calcined to the oxide without loss of these properties. The soluble hydroxide can be prepared as follows: oxide of thorium obtained by ignition of the oxalate is heated with excess of nitric acid, or hydrochloric acid. When the excess of acid is expelled by heating in a water-bath a residue is obtained which is soluble in water.

The patent refers to a co-pending application which became patent 571,531.

571,533, Nov. 17, 1896, Rudolf Langhans, of Berlin, Germany.

Relates to the conversion of precipitated hydroxides, such as described in patents 571,531 and 571,532, into insoluble or difficultly soluble salts, which are easily converted into oxides by heat. The electrode on which the hydroxide is precipitated is connected as an anode, to a weak source of electricity, and placed in a solution containing, for example, selenious acid, tartaric, oxalic, formic, tannic, or carbonic acid; the current immediately transforms the hydroxide into the corresponding salt or salts. The coated body is next removed, washed and calcined.

598,313, Feb. 1, 1889, Ernest P. Clark, of New York, N. Y., assignor of one-half to Charles S. Campbell, of same place.

Relates to depositing lead in a "feathery' finely divided condition. A solution is made by adding 1 lb. 10 oz. of acetate of lead to each gallon of water, the excess of acetate not dissolving being suspended in a coarse cotton bag near the top of the solution. The lead is precipitated as a frothy deposit by clean metallic zinc, the excess of lead acetate dissolving as lead is precipitated, the precipitation being stopped when the solution reaches a specific gravity of 18 or 19 deg. Baumé. The solution will now have a light-brown color.

Upon then inserting a lead anode and lead cathode, and passing a current, a deposit will appear which may at first consist of bright crystals of metallic lead, or a frothy deposit. After some time a feathery deposit will appear; the other deposited lead is then entirely removed from the solution, and deposition continued. After some time the brown color disappears, and the solution becomes entirely clear. The feathery deposit is said to be useful in making accumulator plates. It is stated that a deposit of this character cannot be produced by mixed solutions of zinc acetate and lead acetate.

602,872, April 26, 1898, Joseph W. Richards and Charles W. Roepper, of Bethlehem, Pa.

Relates to producing compounds by electrolysis with an alternating current. An application of the process is as follows: on immersing an anode and a cathode of cadmium in a solution containing 10 per cent of sodium hyposulfite and passing either a frequently reversed current, or an alternating current, sulfite of cadmium will appear as an insoluble coating on each electrode, the hydrogen evolved at the electrodes on reversal, mechanically disengaging the sulfide, which falls to the bottom of the vessel, and keeps the electrodes clean.

607,484, July 19, 1898, Josef Rieder, of Munich, Germany.

Relates to obtaining reliefs in metal by electrolysis for dies, etc., and consists in first making an impression of the relief on a porous block of plaster of paris, etc., or in engraving the same upon a suitable porous stone, saturating the porous block with an electrolyte that will dissolve the metal to be etched, placing the metal to be etched on the impressed or engraved side of the stone, connecting it as anode, and a suitable cathode on the other side of the stone. On passing a current, the anode is dissolved only at the points of contact with the stone, the pressure of the plate against the stone maintaining contact. The plate is eventually dissolved off so as to produce an exact counterpart of the impression in the stone.

A modification shows the lower part of the stone and the cathode immersed in an electrolyte.

## Book Reviews

**Chemical Analysis of Special Steels.** By **Dr. Charles M. Johnson.** Second Edition, rewritten. 438 pages, 39 illus. Price, $3.00. New York: John Wiley & Sons, Inc.

The author is chief chemist of the Park Steel Works of the Crucible Steel Company of America, and his work is devoted to the development of rapid methods, especially for routine work. He covers all phases of the treatment of alloy steels, including annealing and sampling. Numerous methods are given, together with results obtained and precautions required. There are some reprints of papers presented by the author before the American Chemical Society. Methods of analysis of pig iron, carbon steels, together with chapters on raw materials, oils, coal, crucibles, etc., are included.

Plans are given of the Park Works Laboratory, together with photographs, and a description of special appliances, an annealing furnace and a water still. Special apparatus are described and illustrated, and particular attention is given to the laboratory electric furnace. It would have been a valuable addition had the author added an account of his elaborate methods of personal supervision and control over his laboratory force; this should be done in another edition. The book is otherwise most complete and valuable. It should occupy a well deserved position in all steel laboratories.

* * *

**The Metallurgy of the Non-Ferrous Metals.**—By **William Gowland, F.R.S., A.R.S.M.**, 496 pages, 195 illustrations, 4 folding plates. One of a series of treatises written by associates of the Royal School of Mines. Price $5.00. London: Charles Griffin & Co.; Philadelphia: J. B. Lippincott Co.

This book is one of the series edited by the late Sir Roberts-Austen and whose authors are largely his old pupils. As such it deserves respect and attention. This book in particular is not up to the high standard of the series, for it is merely a compilation of data taken from standard American treatises such as Hofmann's, Peters' and Ingalls', and data from the American technical journals. The compilation is, however, well done, and while not as extensive as might be wished, yet the condensed product is available for use by the busy metallurgist, and the book is one which might well be on the shelf of the metallurgical engineer.

# Metallurgical and Chemical Engineering

A Consolidation of ELECTROCHEMICAL AND METALLURGICAL INDUSTRY and IRON AND STEEL MAGAZINE

VOL. XII NEW YORK, NOVEMBER, 1914 NO. 11

PUBLISHED MONTHLY BY THE
McGraw Publishing Company, Inc.
JAMES H. MCGRAW, President.
Secretaryship vacant.
JOHN T. DEMOTT, Treasurer.
239 West 39th Street, New York.
TELEPHONE CALL, 4700 BRYANT.
CABLE ADDRESS, METCHEM, NEW YORK.

ROCKY MOUNTAIN OFFICE........421 Boston Bldg., Denver, Colo.
PACIFIC COAST OFFICE......502 Rialto Bldg., San Francisco, Cal.
CHICAGO OFFICE..........................Old Colony Building
PHILADELPHIA OFFICE................Real Estate Trust Building
LONDON OFFICE............Hastings House, Norfolk St., Strand

E. F. ROEBER, PH.D., Editor.
H. C. PARMELEE, Western Editor.

J. M. MUIR, Manager.

*Yearly subscription price for United States, Mexico and United States dependencies,* **$2.00;** *for all other countries,* **$2.50.** *(European exchange,* **10** *shillings,* **10** *marks,* **12.50** *francs.)*

Copyright, 1914, by the McGraw Publishing Company, Inc.

Entered as Second-Class Matter at the Post Office at New York, N. Y., under the Act of Congress, March 3, 1879.

NEW YORK, NOVEMBER, 1914

EDITORIAL:

"Chemistry in America"........ 669
Progress in Fume Recovery........ 670
Opportunity for Metallurgical Development Due to the War........ 670
The Steel Corporation Dissolution Suit........ 671

READERS' VIEWS AND COMMENTS:

Fire Brick. By Charles S. Reed and J. E. Johnson, Jr.. 672
Grinding Ore for Cyanidation: A Suggested Modification for All-Sliming Practice. By J. V. N. Dorr........ 672
Is There a Complex-Ore Problem? By W. Motherwell and S. A. Ionides........ 673
True Chemical Energies of Combination. By Oscar Brophy........ 674
Cyanide Practice in the Porcupine District. By H. C. Parmelee and H. W. Hardinge........ 674
THE NON-FERROUS METAL MARKET........ 674
THE IRON AND STEEL MARKET........ 675
THE WESTERN METALLURGICAL FIELD........ 676
Chemistry at the American Gas Institute........ 677
Coal Tar Colors in America. By I. F. Stone........ 679
The Situation in the Chemical and Dyestuff Industry........ 684
Chemistry in Lighting........ 684
The Gas from Blast Furnaces, Its Cleaning and Utilization. By J. E. Johnson. Jr........ 685
Quantitative Blowpiping as an Aid to the Prospector. By Siegfried Fischer, Jr........ 693
Coal Gas Residuals. By Fred. H. Wagner........ 696
Niagara Falls Meeting of the American Electrochemical Society. (Report of Proceedings and Abstracts of Papers and Discussions)........ 703
The Hall Process of Desulphurization. By H. F. Wierum.... 718
Chemical Resources of California. By Samuel H. Dolbear.. 720
The Evaporation and the Power Problem in Electrochemical Plants. By Otto Mantius........ 722
NOTES ON CHEMISTRY AND METALLURGY IN GREAT BRITAIN.... 724
RECENT CHEMICAL AND METALLURGICAL PATENTS........ 725
The Electric Crane in the Electrolytic Copper Refinery...... 729
Calorizing........ 730
Present Status of the Fink Furnace........ 731
Gas Blowing Engines........ 734
Rapid Cyanidation of Ore........ 734
Obituary: C. E. Whittlesey and T. J. Grier........ 734
PERSONAL........ 735
DIGEST OF ELECTROCHEMICAL U. S. PATENTS........ 736
BOOK REVIEW........ 736

## "Chemistry in America"

For a brilliant leadership of many years, for many a great advance in science, for many a word and many an act of wise counsel and hearty encouragement, the chemical profession of America is indebted to Edgar F. Smith, Blanchard professor of chemistry at the University of Pennsylvania and provost of this venerable American institution of learning. But no more delightful gift has ever been made by him to his fellow chemists than his recent book on "Chemistry in America." It is a charming book, this story of the early days of chemistry in Philadelphia—a charming story of strong individualities — Woodhouse, Priestley, Cooper, Silliman, and Robert Hare.

In this book we find the annual oration delivered before the Chemical Society of Philadelphia (the oldest chemical society in the world) on April 11, 1798, by Thomas P. Smith. From this address we quote the concluding sentences: "Living as we do in a new, extensive, and unexplored country, separated by an immense ocean from all other civilized nations, we must feel ourselves deeply interested in a knowledge of its mineral productions and this can only be arrived at through the medium of chemistry. As far as our very limited knowledge has yet gone, we have every reason to believe that nature has been far from bestowing her blessing upon it with a parsimonious hand. Abounding as it does with the richest ores of the most valuable metals, we should be committing a crime of the blackest dye, were we through *wilful ignorance* to trample under our feet these invaluable gifts of the Creator.

"The only true basis on which the *independence* of our country can rest are agriculture and manufactures. To the promotion of these nothing tends in a higher degree than chemistry. It is this science which teaches man how to correct the bad qualities of the land he cultivates by a proper application of the various species of manure, and it is by means of a knowledge of this science that he is enabled to pursue the metals through the various forms they put on in the earth, separate them from substances which render them useless, and at length manufacture them into the various forms for use and ornament in which we see them. If such are the effects of chemistry, how much should the wish for its promotion be excited in the breast of every American. It is to a general diffusion of a knowledge of this science, next to the *virtue* of our countrymen, that we are to look for the firm establishment of our *independence.*"

These sentences are as fresh and as true to-day as they were 116 years ago. They raise the question as to the advance made in this period. What a grand and glorious advance has been made in one way, we appreciate by considering simply the present status of American metallurgy in this country's life and in the world's work, while non-metallurgical chemistry has long outgrown agriculture and is conquering daily new fields and creating economic values. But there is another side to the picture. Does the average American—the average business man and the average professional man—grasp any more clearly now than in 1798 the fundamental importance of chemistry in our industrial life? Does the average American now grasp the idea of Smith that it is to a general diffusion of chemical knowledge that this country is to look for the firm establishment of its independence?

A few weeks ago these questions would have been answered truthfully in the negative. But the European war is doing wonders in driving some fundamental facts home to our greatly astonished fellow-citizens. A clearer understanding by the public of the functions of chemistry and of the chemist must be the result. There are innumerable industrial problems that must be solved and can be solved only by the chemist. For the American chemist the situation is full of opportunities —and responsibilities.

## Progress in Fume Recovery

The tremendous amount of costly experimental work that has been done in the treatment of fume from pyrometallurgical operations is beginning to bear fruit commensurate with the preliminary outlay of time and money. Two phases of the problem have had to be considered: the abatement of nuisance arising from the discharge of noxious gases into the atmosphere, and the recovery of metallic waste. The latter is presented in practically every smelting works, regardless of location, and usually both must be solved. In the case of abating a nuisance, the additional problem is presented of making by-products of sufficient value to offset the cost of their recovery, so that if possible the net cost of operation shall not be increased.

A review of the progress that has been made in smelter-fume treatment indicates that the elimination of sulphur dioxide still awaits the commercially demonstrated successful process. Solid constituents of furnace gases can be settled in flues, collected in bags or precipitated electrically by the Cottrell process. Sulphuric acid can be neutralized with metallic oxides, usually zinc, and gathered in bags, or it can be collected also by electrical precipitation together with dust. But none of these methods affects the sulphur dioxide, which escapes to the atmosphere and causes more or less damage depending on the amount of natural or cultivated vegetation near the smelter.

A method of promise for the elimination of sulphur dioxide, and the recovery of elemental sulphur from ores and mattes, is that of Hall, described elsewhere in this issue. By this process the sulphur in sulphide ores is converted into a by-product of value. Sulphur dioxide in the stack gases is reduced to a negligible quantity, far below the amount permissible under the present terms of legal injunctions against smelters. Like other pioneer processes, this one has shown sufficient merit to warrant further testing and experiment; but immediate extension of the work is prevented by the war.

Another possibility in the elimination of sulphur dioxide from furnace gases, which we understand is being investigated, is the use of di-calcium phosphate as an absorbent. It seems that some work by a German chemist suggests the possibility of using this chemical in a cyclic process in which sulphur dioxide might be absorbed at a comparatively low temperature, and later driven off at a higher temperature and condensed.

Returning to electrical precipitation, it is worth while to note some recent developments of importance: a change in the form of the precipitating apparatus, and the possibility of fractionally separating and precipitating the constituents of a furnace gas by varying the temperature.

The former type of treater consisted of metal plates with intermediate wires, the plates forming the collecting electrodes and the wires the discharge electrodes. The type adopted in one of the latest installations consists of iron pipes 5 in. in diameter and 10 ft. long forming the collecting electrodes, with discharge wires supported centrally in the pipes. This form of treater is proving satisfactory, and experiments are being made with pipes up to 18 in. or 20 in. in diameter to meet various conditions.

The discovery that fractional precipitation can be made by successively reducing the temperature of the gas, holds new possibilities; and while it is too early to announce results of this development, its importance will be appreciated when the complex composition of furnace gases is considered.

Still another interesting recent development in electrostatic precipitation is the process for detarring gas described in the American Gas Institute paper of Mr. F. W. Steere. As described elsewhere in this issue, the chief difference from the Cottrell process—and apparently a quite important one—is the use of alternating current instead of high-tension direct current.

## Opportunity for Metallurgical Development Due to the War

While the domestic non-ferrous metal market continues generally dull on account of the war in Europe, there is evidence that in some instances an opportunity exists for new development in this country and a readjustment of the world's metal and mineral industry. We may cite three instances: tin, arsenic, and magnesite. European sources of these materials have played a large part in supplying our own demands, as a brief analysis of the statistics will show.

Among the world's nations the United States is reputed to be the largest consumer of tin. As a producer she is a negligible factor. The value of our tin imports in 1913 was over $47,000,000; the quantity was about 40 per cent of the world's production. Our own output during the same period was 84 tons of 60 per cent concentrates, valued at about $37,000. As we have no important tin deposits, our opportunity lies in the establishment of a tin-smelting industry to treat concentrates that have been going to Europe for reduction. A supply is reasonably close at hand in Bolivia. That country sends annually to Europe concentrates containing 20,000 tons of metallic tin, which is only a fraction of our annual imports. With a dependable supply of ore and competent American metallurgists to design and operate reduction works, the remaining obstacle is a merchant marine to transport the ore.

The consumption of white arsenic in this country last year was roundly 7200 tons, of which we produced only about 2500 tons. The remainder was imported largely from European countries. Arsenic has been a troublesome element in the smelting industry, and while a considerable quantity has been recovered the output could be increased if there was a greater demand and prospect of better prices.

Domestic consumers of magnesite have been dependent mainly on foreign sources of supply. We imported last year 172,591 short tons and produced only 9632 tons. Since Austria-Hungary has supplied the major portion of our imports, the improbability of placing reliance on that source is apparent. Local supplies may be had in California, and although at some distance from Eastern markets, it may be possible to deliver this material cheaply on the Eastern seaboard via the Panama Canal. The Californian deposits are reported to be extensive and high-grade, and the time seems opportune for the advancement of this industry.

### The Steel Corporation Dissolution Suit

The case of the United States against the United States Steel Corporation is now before the judges, just three years after the suit was brought. In the past month the voluminous briefs have been filed and the oral arguments made, before the Circuit Court of Appeals at Philadelphia. There is left, however, an appeal to the United States Supreme Court, in case either party can find grounds for objecting to the decision now awaited, or in case the judges disagree.

While the briefs and arguments on either side deal principally with facts, or alleged facts, the case, of course, really hinges upon the law, and not indeed upon the strict letter of the law, as to how it should be interpreted, but upon how it should be applied. We are now more or less accustomed to seeing the courts decide "trust" cases and order various forms of dissolution, and it is well to point out that all such practices have been built up by the courts. The Sherman law says nothing about dissolutions. It prescribes for any person found guilty a fine not exceeding $5,000, or imprisonment not exceeding one year, or both, and then prescribes that the term "persons" shall include corporations. In case a corporation formed by the purchase of separate units is determined illegal, the Sherman law gives the court no light or guidance other than the bare declaration that the thing is "illegal." It says nothing whatever about dissolutions, that procedure, as in the case of the Standard Oil and Tobacco companies, having been devised solely by the courts under the common law principle that where there is a wrong there must be a remedy, hence the courts have been forced to devise a remedy.

The case of the Steel Corporation becomes peculiarly difficult, because the evidence, about the substantial truth of which there is practically no controversy, shows that the conduct has been progressively better and better. Indeed, the brief of the corporation counsel in substance admits that the consolidations prior to the formation of the Steel Corporation on April 1, 1901, such as the wire, tin plate and pipe mergers, were formed absolutely for the purpose of reducing competition, asserting indeed that such competition was proving ruinous and destructive. As to the conduct of the Steel Corporation itself, the government contentions are chiefly as to what occurred in the early rather than in the later years. Inasmuch as the law prescribes no punishment other than a fine not exceeding $5,000, and imprisonment not exceeding one year, it does not seem that the corporation could be ordered dissolved as a means of punishment for what is passed, even if such punishment could be made to fall upon those guilty. If the court proceeds upon the basis of righting an existing wrong, then it is important to note that the wrongs shown in the testimony and referred to in the arguments, grew progressively less and less.

It is important to note that much has occurred in the steel trade during the three years since the suit was filed, and much that is favorable to the Steel Corporation. Many instances of good conduct were claimed by the Corporation, and admitted more or less by the government, and referring chiefly to the years immediately preceding the filing of the suit. In the three years since then a great deal more of the same character has been developed. There has been a still more open and competitive market. The average of prices has on the whole been lower. The condition of workmen has been improved still more. Indeed, of all the safety and welfare work done to date by far the major part has been done in the past three years. Exports reached a much higher level in 1912 and 1913 than in any previous year. It might be rejoined that possibly the United States Steel Corporation has been particularly "good" during the three years' progress of the suit, but that contention could hardly carry any weight in a court that had assumed the burden of finding a remedy for a discovered wrong; the court would naturally take the condition of the present. We assume that in an appeal to the Supreme Court, at any rate, means could be found for bringing the evidence up to date.

It is interesting to reflect how little interest is popularly manifested in the once famous steel suit. For several months prior to the bringing of the suit it was currently said in the steel trade that business was halting because the suit was impending, and it was predicted that if the suit were brought the steel trade could not become prosperous until it was settled, but the history is that less than a twelvemonth after the suit was brought the steel industry was operating at full capacity and prices were considerably advanced. The whole gamut up and down has been run once, and the steel suit is perhaps still far from its final adjudication.

# Readers' Views and Comments

## Firebrick

*To the Editor of Metallurgical & Chemical Engineering:*

SIR:—I am interested in an article in your August issue by Mr. J. E. Johnson, Jr., which relates to the firebrick business.

From his article I am led to believe that Mr. J. E. Johnson, Jr., is under the impression that the only purpose for which a firebrick is used is in a blast furnace, when he criticises firebrick manufacturers maintaining the standard size of a firebrick at 9 by 4½ by 2½. As a blast furnace is only one of many thousand places where firebrick are used, the manufacturer cannot follow the whim of the blast-furnace superintendent in maintaining his standards at the expense of all the other different users.

A brick smaller than the standard 9-in. square brick costs more to make, owing to loss in warpage and breakage in both the drying and the burning.

The standard sizes of firebrick as adopted by the Refractories Manufacturers' Association comprise all of the *usual* shapes and take a base price, this base price being determined by each manufacturer for himself. It costs more to make the *unusual* thing than it costs to make the *usual* thing. Therefore, based on cost, the firebrick manufacturer is entitled to more money, based on the 9-in. equivalent, when making those sizes which are larger than 9-in. standard.

Mr. Johnson states in his article that it is his opinion, the reason why the manufacturer charges about 20 per cent more for these *unusual* shapes than for the *usual* shapes, is "apparently that he needs it." I would ask if that is the reason why, when purchasing steel, a consumer pays a certain base price for one size and an extra over this base for another size. In this matter of "extras," I was very much interested in an address of a very prominent steel manufacturer given before the Iron and Steel Institute at their meeting last spring in Chicago, and I would suggest that Mr. Johnson refer to this address. It would be interesting to many of your readers to know Mr. Johnson's reasons of the necessity of these "extras" in the steel business.

CHARLES S. REED.

Chicago Retort & Fire Brick Co.,
Ottawa, Ill.

* * *

*To the Editor of Metallurgical & Chemical Engineering:*

SIR:—I am greatly obliged to Mr. Charles S. Reed for his communication on my treatment of the question of firebrick for furnace lining in your August issue, particularly for his comparison of the "extras" on firebrick with those on steel bars, as this comparison furnishes an excellent illustration of my point.

The shapes of which I spoke are the standard ones, Nos. 1 and 2 in keys 9 in. and No. 2 and 4 keys in 13½ in., and the "squares" or straights of those sizes, all of standard thickness, either 2¼ in. or 3 in. These are illustrated as the standard shapes in all the catalogs of firebrick that I have seen. But as I never have seen a catalog of the Reed blast-furnace brick, of course, I don't know whether these are standard with his company or not.

These may be compared with 1-in. and 1½-in. rounds and squares in steel bars.

Now if the price of the latter be made on 1-in. bars as a base knowing that it takes more labor or limits the output to roll a ¾-in. rod, we would naturally expect to pay more per ton for it, though we might be surprised if we had to pay the same price per foot.

This is analogous to the keys of the 9-in. brick; we can see that it costs more per ton to produce them than it does to produce 9-in. straights and the increased price per ton due to their taking the same price per piece is natural and does not arouse any protest that I have ever heard of.

Now let us turn to the case of 1½-in. bars; this is obviously similar to that of the 13½-in. brick. They require less labor and less overhead to produce than 1-in. bars. Do the steel makers say: "We are sorry but we are compelled to charge $2.50 per ton 'extra' for these bars because they are hard to handle"—or could they carry out such a sales policy if they tried? Ask one and see what he says. Yet that is exactly similar to the policy of the brick manufacturers at which my comment was directed.

I believe that Mr. Reed's comparison thus expanded will make clear to him the anomaly in firebrick prices to which I alluded in my article and if Mr. Reed can now explain this anomaly in terms comprehensible to the blast-furnace man with his admitted ignorance of firebrick manufacture in most cases, he will confer a favor on me and, I believe, on many other furnace men.

J. E. JOHNSON, JR.

New York City.

---

## Grinding Ore for Cyanidation: A Suggested Modification for All-Sliming Practice

*To the Editor of Metallurgical & Chemical Engineering:*

SIR:—The general points made by Mr. Pentland, in his article in your October issue, are very well taken as to the necessity of a thorough investigation of the method to be used for treatment of a given ore, in order to provide the most efficient treatment for all portions of it.

I think it has been too common, in testing and in actual operation, to fail to recognize that reground sand is a different ore from the original slime formed from first grinding, although a screen test may eventually be the same on the two materials. I do not question what Mr. Pentland says regarding the necessity of longer agitation, and perhaps the use of a stronger solution, to make the economic recovery from the reground sand; although on the gold ores of the Black Hills, to which he refers in one place, we found that there was nothing gained by using either stronger solution or longer period of agitation on the fine sand, above that required for the slime.

The best method of giving the reground sandy material a separate treatment, providing that tests showed it to be profitable on the whole, is open to question. I would say that Mr. Pentland's proposal to agitate the partly ground material might require a greater total of agitating capacity than the method of agitating all the reground pulp together with the slime, after the first thickener. Where, however, one classifier is used for separating the tube-mill feed from the original slime, and other classifiers are used for removing the reground sand from the tube-mill discharge, his methods would be entirely feasible, except that unless the agitation were done at the dilution of the overflow of these secondary classifiers, it would seem that an additional thickener should be interposed between the classifier and the sand agitators.

In continuous agitation it is usually considered necessary to have at least three agitators in series in order to avoid short-circuiting. Consequently, with separate agitation of the sand and slime pulps, this would mean that the total number of agitators in use would have to be doubled, except in very large plants where the time of agitation is so long that, in order to avoid too large units, more agitators are used than are necessary to avoid short-circuiting. It is well recognized, I think, that with all classes of agitators, and especially with the one I have developed, the cost per cubic foot of agitating capacity decreases with the increase in size of the unit used, so that the cost of three large agitators would be very much less than for six smaller ones. The operating cost for a large unit will also be less per cubic foot of capacity.

I cannot see where agitating the two products separately would affect concentration, as it would undoubtedly be the tube-mill discharge which would be concentrated. Mr. Pentland's suggestion of sending the slime formed from the concentrating tables directly to the thickener, while the sand that needed regrinding would be returned to the classifier, is perfectly proper, but I do not see that it has anything to do with the points made regarding agitation.

Mr. Pentland has discussed the question of our practice of precipitating only the solution from the first thickener, and not the solution from the thickeners following the agitators. Apparently he regards the circulation of this gold-bearing solution through the stamps or grinding apparatus, as likely to cause loss from leakage, etc. The point is well taken; but he has overlooked the fact that if you precipitate from the overflow of the thickener following the agitators, as well as the overflow of the first thickener, it will be necessary to precipitate a great deal more solution per ton of ore in order to have the same final loss, where continuous counter-current decantation is practiced. The cost of this additional precipitation is a very definite one which can be figured quite accurately in advance, and which I believe will greatly exceed the chances for loss in a well-constructed mill, by circulating a somewhat higher-grade solution. In my mind the limit of the value of the solution to be circulated depends upon the efficiency of precipitation, for very low-grade barren solution is essential in continuous decantation.

The Dorr agitator is well adapted for selective agitation, that is, for agitating the coarser or quicker-settling particles of ore a longer period than the finer particles in the same agitator in continuous work; but this would not necessarily allow the finer particles of sand to have a longer or different treatment from the equally slow-settling particles of slime. Mr. Pentland points out that the method he suggests may allow less mechanical loss of cyanide; but if he will note that in a normal flow in continuous counter-current decantation the battery solution coming from the first thickener goes directly to the zinc boxes and from there to the thickener next to the last, he will see that this is the solution the strength of which should be kept as low as possible.

To sum up I would say that if other considerations made it seem advisable to operate tube-mills and classifiers in closed circuit, it is not likely to pay to agitate the tube-mill return, containing partly ground material, separately from the final classifier overflow. If, on the other hand, a separate classifier is used for the reground material, and it can be operated at a dilution of, say, 3 to 1, which dilution is a satisfactory one for agitation, then the agitation of the reground sand might prove quite profitable. The point certainly deserves careful consideration in designing a mill, and Mr. Pentland is to be thanked for calling the attention of metallurgists to it.

J. V. N. Dorr.

New York City.

## Is There a Complex-Ore Problem?

*To the Editor of Metallurgical & Chemical Engineering:*

Sir:—I agree with Mr. Skinner that in the United States so far the flotation process has only been a success on one-mineral separation, the reason being either that metallurgical knowledge is not sufficiently advanced to apply it to complex ores or that there are no payable ores that cannot be treated by ordinary mechanical means. But perhaps only capital is lacking.

I do not agree with Mr. Skinner that "everyone engaged in the metallurgical field is well aware of the work done in Australia." If he is correct, why has the United States been so backward in making use of the process?

Regarding my statement that "it might be worth while to have some experiments made with Colorado complex ores," he says "I already have the proof and he admits that he has not." What proof? Incidentally, I have admitted nothing. He then admits that he has recommended the flotation process "as a subsidiary to the other general operations" (in dealing with Colorado ores). How does he reconcile this with his previous statement that he does not know of any complex ore in Colorado that could possibly show any advantage under this (flotation) treatment?

He then goes on to say "our ores, as a rule, are rather coarsely crystalline so that it is not a difficult matter to make a proper separation by ordinary mechanical means." In other words, he admits that these so-called complex ores are not complex at all. I thought he was referring to ore that so far could not be treated at a profit, and my contention was that the flotation process might be applied profitably to that class of ore.

As Mr. Skinner is so fully cognizant of the work being done in Australia, he must surely know that "selective flotation" is only used on ore, slime or concentrate that is not amenable to ordinary concentration. In that case it would return a much greater, instead of (as he says) less profit to the mine than the "ordinary older means of mechanical separation." It certainly requires operating efficiency (as he says), but is not so expensive as he imagines.

Mr. Skinner's last paragraph is so vague that I am at a loss how to reply to it. If he will specify what proofs he requires against which statements of his, I shall endeavor to supply them. With which situation do I not even admit familiarity? After that there may be further argument. W. Motherwell.

Nacozari, Sonora, Mexico.

* * *

*To the Editor of Metallurgical & Chemical Engineering:*

Sir:—Your September number containing Mr. W. Motherwell's comments on my contribution to "Is There a Complex Ore Problem?" has come to my attention.

His reference is to a quotation of mine about an ore containing 5 oz. of silver per ton, 14.5 per cent lead, 13 per cent zinc, and 0.25 per cent copper, and his assumption, from a similarity of composition, is that this ore was mined at Broken Hill, Australia; as a matter of fact, the ore came from Utah and contained, in addition to the above metals, a large percentage of pyrite which rendered it wholly unadapted to ordinary mechanical concentration. (The insoluble assayed 12 per cent to 13 per cent.) It is possible that this ore might give a fair separation with some flotation method, and I have heard that one already tried has been partly successful. If Mr. Motherwell or any other metallurgist has any solution for this problem, I should be very happy to forward his scheme of treatment or to put him in direct communication with the owner of this property.

In regard to his second comment, stating that the total extraction at the Broken Hill South mine during

| | | Metal Contents | | | | | | Per Cent of Total | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Tons | Pb % | Ag oz | Zn % | Pb Tons | Ag oz | Zn Tons | Pb | Ag | Zn |
| Feed | 168,957 | 14.7 | 7.3 | 14.5 | 24,836 | 1,233,381 | 24,493 | 100 | 100 | 100 |
| Lead cones | 27,594 | 68.1 | 24.4 | 6.6 | 18,782 | 673,465 | 1,821 | 75.8 | 54.2 | 7.4 |
| Zinc tailing | 107,279 | 3.5 | 3.6 | 17.6 | 3,754 | 386,204 | 18,881 | 15.1 | 31.3 | 77.1 |
| Quartz tailing | 12,409 | 1.3 | 1.4 | 5.3 | 161 | 17,372 | 657 | 0.6 | 1.4 | 2.7 |
| Slime | 21,675 | 9.6 | 7.5 | 14.8 | 2,080 | 162,562 | 3,208 | 8.4 | 13.2 | 13.1 |

the second half of 1913, as quoted in the *Mining and Scientific Press,* was 91 per cent lead, 85.6 per cent silver and 84.2 per cent zinc: I have been at pains to find how this extraction was calculated. A fuller account and analysis of the half-yearly report is given in the *Australian Mining Standard* for March 15, 1914, page 186. From this it appears that four products are made: lead concentrate, zinc tailing (for delivery to the Amalgamated Zinc Company), quartz tailing (used as a filling underground), and a slime (stacked for future treatment).

The accompanying table shows the products obtained, the weight of metal produced in each case, and the percentage of total belonging to each class of concentrate. In the *Mining and Scientific Press* the extraction given was obtained by adding the percentages saved in the first two classes, and I believe you will agree with me when I state that this does not give a true result for the total extraction. In the lead concentrate there is 6.6 per cent zinc, amounting to 7.4 per cent of the total zinc in the ore, and while this is saved along with the lead, no credit is given for it in the commercial results; along with the zinc tailing is 3.5 per cent lead amounting to 15.1 per cent of the total lead in the ore, and for this it is exceedingly improbable that any credit would be given.

With regard to the extraction of zinc from this tailing, no figures are given but the credits received in selling the ore amount to from 85 cents to $1.25 per ton, while the gross value of the ore sold to the Amalgamated Zinc Company, with lead at 4 cents per pound, silver at 50 cents per ounce, and zinc at 5 cents per pound would be $22.20. These figures would indicate a commercial saving, which all will admit is the basis of successful mining, of approximately 5 per cent. The assumption that 100 per cent extraction is made from this product, therefore, is very far from being accurate, and Mr. Motherwell's citation is unfortunate and in error.

With regard to the slime product from a lead or copper ore being refractory, I am aware that there are several methods of making a low-grade concentrate from it. If Mr. Motherwell has any way of making a high-grade concentrate from such a product, it would be of great interest to have it more fully explained, rather than hinted at, and I feel sure that there would be a good market for this process.

S. A. Ionides.

Denver, Colo.

## True Chemical Energies of Combination

*To the Editor of Metallurgical & Chemical Engineering:*

Sir:—In your August issue Dr. Carl Hering writes of his investigation of whether it is a mere coincidence or likely to be a possible law that the true chemical energy of each bond between like elements is the same.

It occurred to me that the figures could be made to support this more closely if account was taken of the different kinds of bonds between like elements. In Dr. Hering's table (page 527) the first compound is $CH_4$—here all the bonds are alike, a single bond between carbon and hydrogen—therefore the energy between carbon and hydrogen equals the chemical energy of the compound (+ 61.0) divided by 4 = 15.25. But the next compound $C_2H_2$ has two kinds of bonds. It may be written $H - C \equiv C - H$. The value of the two single bonds equals + 30.5, subtracting this from the chemical energy of the compound (+ 32.8) leaves + 2.3 as the value of the triple bond between two carbon atoms. The third compound is written $H_2 = C = C = H_2$. By the same method the value of the double bond is found to be + 8.6 and of the single bond between two carbon atoms + 16.0.

Energy between hydrogen and carbon atom = 15.25 kilogram calories.

Energy between 2 carbon atoms—single bond = 16.00 kilogram calories.

Energy between 2 carbon atoms—double bond = 8.60 kilogram calories.

Energy between 2 carbon atoms—triple bond = 2.30 kilogram calories.

With these four values the chemical energies are calculated by writing out the structural formula, giving each kind of bond its value and adding together. The results are tabulated below and are arranged with each series of compounds grouped together.

| Compound | Chemical Energy | Calculated Energy | Difference |
|---|---|---|---|
| $C_nH_{2n+2}$ | | | |
| $C_3H_8$ | + 156.8 | + 154.0 | — 2.8 |
| $C_4H_{10}$ | + 203.5 | + 200.5 | — 3.0 |
| $C_nH_{2n}$ | | | |
| $C_3H_6$ | + 116.9 | + 116.1 | — 0.8 |
| $C_4H_8$ | + 171.0 | + 162.6 | — 8.4 |
| $C_5H_{10}$ | + 217.8 | + 209.1 | — 8.7 |
| Benzene | | | |
| $C_6H_6$ | + 241.3 | + 165.3 | — 76.0 |
| $C_7H_8$ | + 289.3 | + 211.8 | — 77.5 |
| $C_8H_{10}$ | + 330.0 | + 258.3 | — 71.7 |

This table contains those compounds of which there are more than one of a series in Dr. Hering's table. Except for the compound $C_3H_6$ there is a constant difference between the two values for each series of compounds. Does this mean that the energy of condensation is a constant for each series of compounds?

Oscar Brophy.

Philadelphia, Pa.

## Cyanide Practice in the Porcupine District.—A Correction

*To the Editor of Metallurgical & Chemical Engineering:*

Sir:—In the table giving a comparison of methods adopted in the principal cyanide mills at Porcupine, page 636 in your October issue, I note an error in the column devoted to classifiers. The Dorr classifier is used at the Dome mill, and the Colbath at the McIntyre, instead of *vice versa* as published.

H. C. Parmelee.

Denver, Colo.

* * *

*To the Editor of Metallurgical & Chemical Engineering:*

Sir:—In your last issue we note an article in regard to the operation of the Hardinge mills at the McIntyre plant in the Porcupine district. While the remarks ordinarily would be flattering they do the Hardinge mill a great injustice in stating that the material fed to the mill is ¼ in., while in reality it would not all pass a 1½-in. screen. If we assume it to be 1 in., which is not in itself as coarse as is being fed to the mill, still this 1 in. would be sixty-four times the volume of ¼ in. —in other words, the Hardinge mill has received credit for only doing 2 per cent of the actual work it is performing.

This also applies to the Vipond plant, where a similar size material is being fed; in other words, the Hardinge ball mill is taking a stamp-mill feed.

H. W. Hardinge.

Hardinge Conical Mill Co., New York City

## The Non-Ferrous Metal Market

A general decrease in prices has marked the metal markets during the past thirty days. Regular copper quotations have not been resumed, and the prices at which sales are made are erratic and much below normal.

**Copper.**—Domestic demand has not improved much, and exportations are small. Sales have been made at about 11.5 cents, and there seems to be no immediate hopeful outlook for improvement.

**Tin.**—The demand for this metal has fallen off, and prices have consequently declined. The latest quotation is about 29¾ cents, New York.

**Lead.**—New York price has been reduced to 3.5 cents per pound, with little effect in stimulating business. St. Louis quotes 3.35 cents.

**Spelter.**—Both domestic and foreign demand has fallen off and prices are lower. The decline has been steady to about 4.65 cents, New York, and 4.50 cents, St. Louis.

**Other Metals.**—Quicksilver continues strong, with New York prices ranging about $55 per flask of 75 lb. Business in antimony has been fair, with prices from 11 cents to 13 cents for various brands. Quotations for aluminium are 18@19 cents, New York, with little actual trading.

---

## The Iron and Steel Market

The iron and steel market has dropped to the lowest depths of stagnation seen for many years, perhaps, indeed, since the steel trade replaced the iron trade about a quarter century ago. The stagnation is due more to a mental than a physical state. Demand is light, not because buyers are overstocked, because prices are too high or because physical conditions do not call for the consumption of steel.

The depression is due in part to financial conditions and in part to extreme timidity on the part of buyers, bordering upon panic. It is not difficult to trace the development of thought through which the present condition was brought about. Immediately upon the inception of the European war the steel trade was filled with talk of an immediate expansion in demand, both domestic and export, and with fears that there would not be ferromanganese and magnesite sufficient to permit the steel being made that would be called for. A distinct though slight buying movement about the middle of August furnished concrete evidence that these views were more or less accepted in practice. Later it became certain that there would be no scarcity of any raw material and that the export demand would, for a time at least, prove very light. Money became tight immediately after the war started, but evidently it was weeks before business men realized how seriously the condition would restrict industry. Thus, on account of mistakes in judgment made in August the full measure of the depression has developed only of late, when with a quicker apprehension of the true state of affairs it is not impossible that by this time we should have been able to set ourselves on the road to recovery.

Steel buying has been constantly diminishing and has now reached a very low ebb, the total bookings, in specifications against contracts and in new purchases, chiefly the former, probably not comprising more than 30 or 35 per cent of the existing capacity. Declines in production have followed declines in buying, until at the close of October the average rate of steel mill operation is only about 40 per cent of capacity, against an average between 65 and 70 per cent of capacity during July and August.

Never before, as already indicated, has the steel market reached such a stage of stagnation. In all previous instances there has been a rebound when the rate of production dropped to about 50 per cent, but precedents are regarded as no criterion as to what may occur under these war conditions. So many mistakes having been made already, however, that the conservative observer need not take the popular judgment as final. Perhaps, after all, recovery will set in sooner than is generally expected.

The export demand for steel mill products is running at a rate well under the rate obtaining in the first half of the year, even though that rate, some 140,000 tons a month, was far below the record rate, about 245,000 tons as the monthly average of 1912. There is no prospect of any early and important improvement. The buying capacity in our regular export markets has been greatly reduced, and particularly in South America. The new export demand, for England, which early in the war gave considerable promise, has proved to be light, as activity in the British steel trade is so light that the flow of unfinished steel from Germany and Belgium, stopped by the war, does not necessitate the placing of any large orders in the United States. There has been, however, a fairly heavy demand for barb wire and nails from England, and to a lesser extent from Russia.

At midsummer stocks of finished steel in the United States were thought to have reached the lowest possible level, but they are now much smaller. Nothing approaching a close estimate can be made as to the actual rate of ultimate consumption, since the war has practically stopped the inception of new enterprises, while an indeterminate part of the consumption in recent weeks has been in projects already in course.

In one direction there has lately appeared considerable promise of improvement. While the steel trade has not directly felt any stimulus in export demand for its products, a considerable export demand has undoubtedly appeared in several other directions, including some industries that consume steel. Some large orders have been placed, for instance, for motor trucks and for lathers and other machine tools for export.

Steel buying has been so extremely light that prices are not seriously tested, but there has been a more or less declining tendency nevertheless, and where the end will be cannot be guessed. If the cost of production has been the determining factor in previous declines, and is to determine at this juncture, then the decline will not be to as low a level as in the past, for the mills will have a lower rate of production and consequently higher costs.

### Pig Iron

The rate of merchant pig-iron production has dropped to the lowest level in many years, and yet some iron is being piled, so that the trend is still towards a decrease in output. Buying is almost absent, but enough has occurred to develop slight declines at several points, and there is likely to be further yielding. Southern pig iron, while remaining at $10, Birmingham, is lower at many delivered points on account of the reduction in freights. The rate to Cincinnati has been reduced from $3.25 to $2.90; to Chicago from $4.85 to $4.50 and to Pittsburgh from $4.90 to $4.55, though practically no Southern pig iron has gone to the Pittsburgh district for years. Prices are now approximately as follows: No. 2 foundry, f.o.b. Birmingham, $10; delivered Philadelphia, $14.20; f.o.b. furnace, Buffalo, $12.25; f.o.b. furnace, Chicago, $13; at valley furnaces (90 cents higher delivered Pittsburgh); Bessemer, $14; basic, $12.75; No. 2

foundry and malleable, \$12.75 to \$13; gray forge, \$12.50 to \$12.75. Ferromanganese has continued to weaken. The English price, on contract, is \$68, Baltimore, but re-sale material is offered for prompt shipment at \$65 or less, and there is practically no buying.

### Steel

A few sales, and a greater number of offerings, have developed considerably lower prices for billets and sheet bars. Consumers have old tonnages still due them and being confronted with very light operations for the near future are buying practically nothing. Billets are quotable at \$19.50 and sheet bars at \$20, at maker's mill, Youngstown, prices at maker's mill, Pittsburgh, being 50 cents higher. Rods are \$26, Pittsburgh, but are practically nominal at that figure.

### Finished Steel

Current prices as far as developed are practically as follows, f.o.b. Pittsburgh, unless otherwise stated:

Rails, standard sections, 1.25c.; for Bessemer, 1.34c. for open hearth, at maker's mill, except Colorado.

Plates, tank quality, 1.10c. to 1.15c.

Shapes, 1.15c.

Steel bars and bands, 1.15c.; hoops, 1.25c., base.

Iron bars, 1.15c., Pittsburgh; 1.00c. to 1.05c., Chicago, 1.17½c., Philadelphia.

Sheets, blue annealed, 10 gage, 1.40c.; black, 28 gage, 1.90c.; galvanized, 28 gage, 2.90c.; painted corrugated, 2.10c.; galvanized corrugated, 2.95c.

Steel pipe, ¾ in. to 3 in., 80½ per cent off list.

Steel boiler tubes, 3½ to 4½ in., 72 per cent off list.

Standard railroad spikes, 1.40c., Pittsburgh; 1.50c., Chicago.

Structural rivets, 1.45c.; boiler rivets, 1.55c.

Cold-rolled shafting, 67 per cent off list.

Chain, ⅜-in. proof coil, 3.00c.

---

## The Western Metallurgical Field

### Heating Mill Buildings

As a general rule the cyanide and concentrating mills of the western United States require heating during the winter season. In some cases it is even customary to heat solutions throughout the year. For both of these purposes steam must be generated, either in conjunction with the power plant, or for the sole purpose of heating when electric power is purchased from a central station. In either event it is likely that live steam is used in most cases, and that heating with exhaust steam is not practiced to a wide extent.

There are neglected possibilities for economy in the use of exhaust steam for heating purposes. If a mill has a steam power plant, and live steam at reduced pressure is used for heating, there is a distinct loss in the waste of exhaust steam from the engines. If, on the other hand, the mill is supplied with electric power from a central station and a steam plant is installed for heating purposes only, the cost of that heating is almost as great as though a corresponding amount of power were first generated and the exhaust steam used for heating.

The relative fuel requirements for heating and for power production are not always fully appreciated. Writing on the subject of Preventable Losses in Factory Power Plants, Mr. David M. Myers gives some illuminating facts in the August number of the *Engineering Magazine*. Among other things he shows that about 90 per cent as much fuel is required to make live steam for heating requirements alone as for the production of power. In one case he demonstrated this by shutting down every engine in the plant and weighed the fuel to the boilers which carried a heating load only, with the result that there was no perceptible difference in fuel consumption. In a case where steam at 125 lb. was lowered to 20 lb. by a reducing valve for the heating system, a 150-hp non-condensing Corliss engine was substituted for the reducing valve, expanding the steam down to atmospheric pressure before it was used for heating. The power thus produced, or about 90 per cent of it, became a pure by-product of the steam heating. It is essential, of course, that an exhaust-steam heating plant be properly designed, for otherwise the beneficial effects cannot be obtained and failure is likely to result.

Another point made by Mr. Myers is contained in the following quotation: "A common error among plant owners is to ascribe undue economy to the heat that may be carried in water resulting from the condensation of steam. They conversely greatly *underestimate* the heat carried in exhaust steam. As a matter of fact the heat in a pound of water at 212 degrees is only 180 British thermal units reckoned above the freezing point; whereas in a pound of steam *at the same temperature* the heat units number 1150. Hence if this steam is condensed in a radiator it gives out 970 heat units, and the drip will contain 180 heat units. Nevertheless I have found the management very anxious about correcting the loss due to a few escaping drips, while at the same time large quantities of uncondensed exhaust steam were blowing away almost unnoticed. Pound for pound, the waste which attracted the manager's attention was equal to less than *one-fifth* of the heat being carried away in the disregarded exhaust steam. This is a good thing to remember, and it will stand twice telling: *Utilization of the exhaust steam saves five times as much coal as the return of an equal weight of hot drips to the boiler.*"

The whole subject of heating with exhaust steam is worthy the attention of metallurgists because it is quite possible that important economies can be effected in connection with the power plant.

### Anyox Smelter of the Granby Company, British Columbia

The new smelter erected by the Granby Consolidated Mining, Smelting & Power Co., Ltd., at Anyox, B. C., was designed to treat the ores from the Hidden Creek mines near Granby Bay, on Observatory inlet, about 110 miles northeast of Prince Rupert.

Each of the three blast furnaces measures 50 in. by 360 in. at the tuyeres. The sole plate is four inches thick and is formed of iron cast about coiled pipe through which cooling water is circulated. There are two rows of jackets; in the lower row on each side of the furnace there are six, each 54 in. wide, and one tap-hole jacket 36 in. wide. All are 10 ft. 6 in. in height. Those in the upper row are 60 in. wide and 6 ft. 8 in. in height. The tuyere openings contain thimbles that are fused to the fire sheet, extending through the air sheet of the jacket and beaded in place. The upper tier of jackets is supported from the mantle frame in such a way that the lower jackets can be removed without disturbing the upper tier.

The mantle frames of the three furnaces are connected, forming one continuous mantle. The sole plates extend beyond the end jackets, and it will be possible to extend the furnaces at any time to occupy the space of 15 ft. which intervenes between the middle and end furnaces, so that a single furnace of 120 ft. in length could be constructed without difficulty.

There are three basic-lined copper converters of the Great Falls type, each 12 ft. in diameter and 17 ft. 7 in. high. Thirteen tuyeres 2 in. in diameter are placed with their axes at right angles to the axis of the shell. The tuyere pipes extend into the converter and are connected with the tuyere casting by a special coupling which permits removal of the casting without interfering with the pipes. Each converter is operated by a 50-hp motor through worm gears.

Additional information on this and other smelting plants in British Columbia is contained in a publication recently issued by the Department of Mines of Canada. The report, which is edited by Dr. Alfred W. G. Wilson, presents a historical review of copper smelting in Canada and includes descriptions of the plants now in operation: Canadian Copper Co., Mond Nickel Co., Consolidated Mining & Smelting Co., Granby Consolidated M. S. & P. Co., British Columbia Copper Co., and Tyee Copper Co.

## New Cyanide Mill for Rochester Mines Co., Nevada

The design of the new 100-ton cyanide mill for the Rochester Mines Co. at Rochester, Nevada, construction of which is now under way, presents some interesting features, particularly with reference to continuous counter-current decantation. The equipment of the sampling department comprises the following machines in sequence: Blake crusher, elevator, No. 3 Vezin sampler, Dodge crusher, No. 2 Vezin sampler, rolls, and No. 1 Vezin sampler. Metallurgical treatment will begin by crushing in solution with ten 1550-lb. stamps. The stamp discharge will be classified into sand and slime in a Dorr classifier specially designed to give extra settling area, being deeper and longer than the standard machines. The grinding will be completed in two 5 ft. by 16 ft. tube mills connected by clutches with a single 100-hp motor equipped with silent-chain drive. The classifier overflow will contain probably 95 per cent of minus 200-mesh pulp.

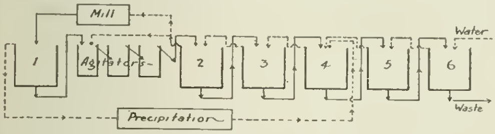


FIG. 1 — SCHEME FOR CONTINUOUS DECANTATION AT ROCHESTER MILL

The equipment for recovery of pregnant cyanide solution will consist of one Dorr thickener 28 ft. by 12 ft., followed successively by three Dorr agitators 28 ft. by 16 ft., and five thickeners 28 ft. by 10 ft. The agitators will be operated in series, with a drop of four inches between successive machines. The last five thickeners have, successively, 2 ft. greater elevation to provide for return of decanted solution by gravity. Diaphragm pumps will be used to elevate the thickened pulp through the series. The pumps will be driven from adjustable eccentrics on an overhead shaft, a 7-ft. rod connecting the diaphragm with the drive. This scheme is expected to materially lessen the wear on the diaphragms due to lateral motion.

The general scheme for continuous decantation which was finally adopted after considering the conditions peculiar to this proposition, is diagrammatically represented in Fig. 1. It will be observed that there are six thickeners, five following the agitators instead of four as is customary in other installations. It was first proposed to use only five altogether, with double precipitation, precipitating not only the overflow from No. 1, but also that from No. 4. Under this scheme, the theoretical calculations indicated a loss of dissolved gold amounting to four cents per ton of ore treated, and a mechanical loss of cyanide equal to 0.61 lb. per ton of ore. The calculations for the present scheme, however, using six thickeners and single precipitation, indicated dissolved loss of about one and one-half cents per ton of ore, and a mechanical loss of cyanide equal to 0.62 lb. per ton of ore.

Comparison of the figures will show that the extra decantation obtained in the sixth thickener, reduced the dissolved loss and still gave about the same mechanical loss of cyanide. A further reason for the adoption of the extra thickener was the possibility of occasionally treating high-grade ore—up to $50 per ton—in which case the extra decantation would be a protection against loss of dissolved metal. It is interesting to note that a 15-hp motor provides power for all operations below the tube mills.

## Chemistry at the American Gas Institute

The meeting of the American Gas Institute, held in New York City from October 21 to 23 in the United Engineering Building, brought out some interesting chemical papers, mostly presented before the new Chemical Section.

A paper of considerable chemical interest, by Captain **Fred H. Wagner** of the Bartlett Hayward Company, of Baltimore, Md., on "coal gas residuals (Feld process)" was presented on October 21 before the Manufacturing Section. It is published in full elsewhere in this issue.

The chief chemical feature of the convention was, however, the inauguration of the newly formed Chemical Section. It was very successful in both its sessions in the morning and afternoon of October 22. While the members were somewhat tardy in coming in, the meeting room filled up very well in time, the attendance being somewhat like fifty. Moreover, there were good spirited discussions and the interest did not flag to the end.

### Gas Analysis

The proceedings of the morning started with a report by **W. H. Fulweiler**, Philadelphia, Pa., for the Gas Chemists' Handbook Committee. The voluminous first report of 118 printed pages gives first an alphabetical index of what should be included in the Handbook, and secondly a description of methods of analysis of ammoniacal liquor, coal and coke, illuminating gas and furnace gas, impurities, gas oil, oxide, and tar. Mr. Fulweiler emphasized that standard methods of sampling were at least as important in practice as standard methods of analysis.

A long discussion followed in which Dr. Morehead and Dr. Elliott emphasized that the ultimate object of the work of the Committee should be a set of standard rules for sampling and analysis which would have to be adopted by the Gas Institute (like the Standardization Rules of the American Institute of Electrical Engineers). These rules would represent the final authoritative say in cases of dispute between seller and buyer of coke, for instance.

A paper on "a method for the determination of hydrogen sulphide in gas" was then presented by **A. B. Way** of Everett, Mass. There was a lively discussion on "pet analytical methods." The general consensus of opinion seemed to be that Mr. Way's method was both accurate and quick.

### An Electrical Process for Detarring Gas

Of considerable interest and great promise for industrial application was the paper by **W. W. Steere**, Detroit, Mich., on a process which he has recently worked out, having formerly been connected with the research work of Prof. A. F. White, of the University of Michigan, on the electrical separation of tar from coal gas by the Cottrell process. While Cottrell uses rectified high-tension direct current, Steere employs alternating current directly. This means simplicity of construction since with the simple use of alternating current the transformer may be mounted on the ionizer, one terminal may be grounded and the other connected directly to the electrode terminal. With the terminals and connections completely enclosed so that no high-tension parts would be exposed, and with no moving parts requiring attention or inspection the element of danger would be absolutely eliminated.

The process was worked out at the Detroit plant of the Semet-Solvay Company. The gist of the process is this: It is practically impossible in mechanical extractors to free the gas from tar in the extremely fine state of subdivision which naturally results from rapid condensation. But there is no difficulty in removing relatively large drops. Now the electrical treatment simply converts the fine mist into large drops.

The gas is subjected to an electrostatic treatment in the "ionizer" operated by alternating current, and the result of this treatment is that the fine mist of minute tar globules is agglomerated into large drops. The gas with the large tar drops is then swept into some form of mechanical extractor where a complete removal is affected with very little power loss. The Doherty centrifugal tar extractor worked very well to accomplish this; the old type P and A machine also became a very efficient tar extractor when placed after the ionizer.

Cleaning producer gas for use in gas engines is one of the later developments of this process and it is noteworthy to state that the process is now in commercial use at the plant of the Ford Motor Company at Detroit on the producer gas driving their large gas engines. The process was started at the Ford plant the 21st of January, 1914, and up to now has not been out of service one minute while the plant was running.

The paper elicited an extended discussion and in reply to the various questions asked, Mr. Steere stated that there is no decrease in calorific power of the gas. No deteriorating effects have been observed on the iron mains in nine months' work. The process is electromechanical rather than electrochemical. At the Ford plant the power consumption is between 1 and 1½ kw. The problem of insulating has been solved completely.

We expect to publish this interesting paper in full in a future issue.

### Calorimeter

A paper on "tests of a new recording calorimeter" was next presented by C. H. STONE, Middletown, N. Y., and W. H. HINMAN, New York City. The instrument, built by the American Meter Company, is a regular Hinman-Junkers calorimeter fitted with a pair of special recording thermometers. The paper was read by Mr. Stone and the discussion closed by Mr. Hinman. In the discussion various speakers emphasized the great commercial need of a reliable recording calorimeter. The instrument was shown in the exhibit of apparatus on the ground floor of the building.

### Bureau of Mines

The afternoon session was devoted to these papers contributed by the Bureau of Mines.

Dr. G. A. BURRELL presented a paper, by himself and I. W. ROBERTSON, on "the separation of the illuminants in mixed coal gas and water gas."

In this paper experiments were described made by the Bureau of Mines and which resulted in separating the illuminants in the mixed artificial gas of Pittsburgh. This gas is made by mixing one part of carbureted water gas with three parts of coal gas. The separation was made fractionally distilling the gas in a vacuum at low temperatures and follows the method detailed by the Bureau in separating natural gases.

Dr. HORACE C. PORTER then presented a paper by himself and GUY B. TAYLOR on "the mode of decomposition of coal by heat." The object of the research was to analyze the process of carbonization in its different steps and to study especially the early steps by making use of a high vacuum with low temperatures of decomposition.

### Gas Manufacture from the Point of View of Physical Chemistry

The last Bureau of Mines paper was presented by Dr. W. F. RITTMAN, who spoke forcefully and very interestingly. The day is past when gas making is primarily a mechanical operation. Carbureted water gas constitutes approximately two-thirds of the gas made today, and it is no longer possible to buy a high-grade paraffin gas oil for 3 cents a gallon. In 1913, Greater New York alone used approximately 3,860,000 barrels of oil in the manufacture of carbureted water gas. During 1913 the same plants used approximately 1,600,000 tons of coal. On the basis of heat units involved, oil has become as important in American gas manufacture as coal. During the last decade, the increasing price of oil for gas manufacture has created what many gas men regard as a "dangerous" situation; and this is true despite the fact that never before in the history of the United States has so much oil been produced as to-day.

The reason for this is to be found in the fact that the oil refiner, by extended research, has perfected processes whereby the oil which the gas manufacturer used to buy at 3 cents a gallon is now converted into gasoline and other products which sell at several times that price.

In a recent court hearing in Chicago interesting testimony was given by Mr. Frank B. Lewis, Jr., manager of the Standard Oil Company refinery at Whiting, Ind., regarding the Burton process. The Whiting plant is running exclusively on Mid-Continent oil. They are able to take it all and convert it all into gasoline except what coke is left in the still, and a little wax or petroleum tailings. The process has been in use for about one year.

Oil refiners all over the country are also working on methods to convert every pound of gas oil into more valuable products. Facing facts, this means that if gas men are to continue the use of petroleum in carbureting water gas, they must resort to one of two alternatives: first, they must greatly increase the yield of gaseous hydrocarbons from a given amount of oil, or second, they must perfect methods of using the millions of barrels of fuel oil which today are considered unfit for carbureting water gas. One often hears the statement that these so-called fuel oils cannot be used in carbureting water gas. What right does any one have to make this statement?

Dr. Rittman thought there is no reason to be pessimistic. He expressed the conviction that as soon as the gas manufacturer faces facts as they are, and seriously attacks the problem, increased efficiency and economy will result with petroleum still of primary importance as a raw material. Never in the history of the world has so much oil been produced as is being produced today. It is estimated that Oklahoma alone will mine 80,000,000 barrels. California will contribute 100,000,000 barrels. Never in the history of the United States has so much oil been in storage as today. We are not facing an oil famine. We are facing a famine of knowledge concerning the chemical behavior of inferior petroleums which will facilitate their substitution for higher-grade petroleums.

Dr. Rittman emphasized the necessity of systematic physico-chemical research at considerable length.

The different papers are copyrighted by the American Gas Institute, subject to the authors' corrections.

## Coal Tar Colors in America*

BY I. F. STONE

It gives me great pleasure to be able to appear before you this evening, to clear up if I can, the general skepticism which seems to exist in connection with the manufacture of coal tar dyes in the United States.

That there is such an industry in the United States is a fact and has been for over thirty years. That we cannot compare with Germany in magnitude is, of course, true, and that we will be able to increase our production in the near future to take over all of the colors now supplied by Germany is also manifestly impossible, but that it is possible to increase the American production very materially is a fact, depending on certain conditions of which I will speak later in my remarks.

That there has been more or less prejudice against dyes made in America is also true, in spite of the fact that these dyes are fully as good as any made in Europe, and it has been a struggle to prove that the latter statement is absolutely true. Even at this late day there are people who would always give the preference to European dyes at the same price and quality, if they had an opportunity to do so, and are abetted in their belief very naturally by the European representatives. Only a few days ago among other letters we have received asking about the manufacture of dyes in this country, was one from a very substantial trade journal which circulates largely among the textile mills. Among other things it says:

"No one believes that the American dyestuff manufacturer can compete with the German. The Germans are counted wizards in dyestuff chemistry, and I doubt if you could interest a great number of manufacturers in a domestic product at the same price as quoted on exactly the same thing from Germany."

After a couple of pages of such argument it finally suggests that we take up the matter of advertising with them to change the sentiment of the buyers, which is very naive to say the least. But the point is if a journal with the influence of this one should express such sentiments among its subscribers, how unfair it would be to the American manufacturers of dyes, and it is simply an instance of one of the small things against which they are struggling.

On the other hand, in the past few weeks we were encouraged by numerous letters from actual consumers of dyes, among them some of the largest textile mills in the country, complimenting us upon the way we have been handling our products during the present abnormal conditions, and advising us that they would in the future give their preference to American colors whenever we are able to offer them in competition with foreign colors; in other words, able to supply them with the quantity of colors consumed, which hitherto we have not been able to do by reason of not having a production sufficiently large to take care of all the trade. So life does have its compensations and the American dyestuff industry from now on, in any event, starts out on an equal footing with the German industry, as far as the good-will of the consumer is concerned, and it is, therefore, only a question of being able to produce a large enough quantity at competitive prices to insure a large proportion of the business of the United States for the American manufacturers.

Barely two months ago a comparatively small percentage of the population of the United States knew anything about aniline dyes or dyestuffs, those who did know something being mainly connected with industries which used these products in their line of business. Even those who did use them had only a vague idea, as a rule, what they were and their source, except in a general way that they were made from coal tar and that Europe was the principal source of supply. They were even regarded by a large percentage of the consumers as a mere detail of their business, and were put in among the sundries with such items as oil, soap, and I might almost say paper, string, and such miscellaneous supplies, notwithstanding that it required the highest order of scientific training to produce these colors and a long experience and knowledge of them in order to sell them successfully. The average dyestuff salesman was received only with tolerance and usually referred to some minor employee of the owner for his interview.

Suddenly something happened. A great war was declared, and the great source of supply was one of the principal nations involved. Some buyer, more intelligent than the ordinary one, discerned that the supply of dyestuffs would be more or less limited if not entirely cut off under these conditions, and immediately made attempts to secure a good supply for his future wants. The news soon spread among others until there was a general scramble for dyestuffs, and men who ordinarily gave this matter very little attention are now looking after it personally, and interviewing and corresponding with the heads of such firms as they thing can supply them with their wants. The newspapers took up the matter and published columns of more or less accurate information as to the situation. The general public was, therefore, given an idea of what was going on, and now know more of the source and supply of aniline products than they ever knew before.

The unfortunate conditions now prevailing have at least been of some good in a small way in educating our people here to the fact that they should be as independent as possible of other nations in connection with their supply of such products as are needed in this country, and there is now a general demand that the production of aniline dyes as one item should immediately be developed to such an extent that we would be independent of all other nations.

The serious question now, therefore, is whether or not such industry can be developed to such an extent, and this question can only be answered by some extended and more or less superficial explanation of conditions. It is not my intention to put before you a scientific or technical paper on the subject, as most of you are more or less familiar with the general conditions surrounding the manufacture of these products, or at least can easily read up in detail in any of the standard publications on the subject. I do wish to give you, however, a practical statement of the facts so that you will see why the industry has not developed in this country as it has in Europe, more particularly in Germany, as other nations are no further advanced than are the United States.

Aniline, as you know, is a product of coal tar, that is, coal tar is the primary raw material from which colors are produced, and it was obtained originally in the manufacture of coal gas, but of recent years a large and constantly increasing quantity has been obtained from the coke ovens used for making hard coke.

The first distillates are such products as benzol, toluol, xylol, phenol (carbolic acid), naphthalene, anthracene, etc., and these are produced largely in the United States as well as in Germany. Benzol, for instance, which is probably the most important of the group, is not only used as a base for the manufacture of intermediate products for the manufacture of aniline dyes, but is also used largely as a solvent in place of benzine and gasoline, and, in fact, in Europe is used largely as a fuel for automobiles as a substitute for the same products. The prices at which it sells in this country are practically the same as in Europe, as are also, in fact, the prices of the other distillates first mentioned.

---

*A paper read before the New York section of the American Chemical Society on October 9, 1914. A report of the meeting will be found elsewhere in this issue. (See p. 684.)

Up to now the supply has kept pace with the demand and there is no overproduction, but if the manufacture of dyes is to be considerably extended it will then be also necessary to extend the production of benzol, and this can be done in the course of time by getting the assistance of those coke ovens which do not at present recover their benzol, to put in appliances for doing so. Their interest in the matter, however, depends on their ability to make a profit on this recovery. There is, therefore, a chance that the price of benzol may increase to some extent for this reason.

Another of importance is naphthalene, which is made largely because there is a large demand for it, the consumption in the United States being upwards of nine or ten million pounds, not alone for its use in the manufacture of dyes but more for its use as a moth preventive, it having a large sale for this purpose all over the land. Of the quantity consumed here about one-third is produced in the United States, while the balance comes about equally from Germany and England.

It is evident, therefore, that the United States starts out on an even basis with Europe as far as the supply of the first raw materials is concerned, and that the natural resources of this country are available for an increase in the products which are manufactured from this source. So, in the beginning, for raw material we are as well placed here as they are in Germany; in other words, this is not a hot-house industry as some people have claimed, but is a part of the natural resources of the United States.

From these distillates are manufactured what we call intermediate products, such as nitro-benzol, aniline oil, aniline salts, toluidine, xylidine, cumidine, benzidine, binitro-benzol, nitro-benzol, sulfo-acids, and a host of other products, a list of which can be had from any good textbook on chemistry if you are interested in looking them up further.

It is here that the first check in the economical manufacture of aniline dyes is encountered, for the reason that with one or two exceptions which I will mention later, none of these intermediate products are manufactured in the United States, because up to now there has not been a large enough demand for them to make their manufacture economically possible, while on the other hand, Europe—Germany particularly– has so developed the demand for these intermediate products that many plants have been established for their manufacture, most of them specializing on certain products, while some specialize on others, so that in the aggregate they are all produced on the most economical basis.

Up to within recent years few of the aniline dye manufacturers manufactured these products themselves, but depended largely on the aforementioned so-called specializing factories for their supplies, but this is now changing and some of the large color manufacturers are now making the principal intermediate products themselves although none of them make everything which they use. It is then very necessary, if the United States is to be independent of Germany, that these intermediate products be manufactured on a large scale in this country, and it is here that we ask the Government to start in with a sufficient protective duty to allow the business to be developed. The present duty of 10 per cent, which was only put on in the last Tariff Bill, is really not sufficient for the purpose, while before that time the group being free of duty there was no incentive to begin their manufacture here.

One exception which is manufactured here is aniline oil, the manufacture of which was commenced about three years ago, and the quantity now produced is about one-quarter, and perhaps more, of the total consumption of the United States, taking oil and salts as one product. The quality is very satisfactory as compared with the German and English products, and has been used by our factory in the manufacture of aniline dyes since the beginning. In fact, if it were not being produced in this country at the present time the American dye manufacturers would not be able to continue to run, as they would be unable to obtain supplies from Europe. Consequently, as a result of this, manufacturers here are able to relieve the scarcity of aniline dyes, and have been of great benefit to American consumers by so doing, and will be a great factor in this relief as long as these unfortunate war conditions continue, so illustrating the great benefit to the people at large in having this class of products manufactured here, and so be entirely independent of Europe, under any conditions.

Unfortunately, however, the commercial side of the manufacture of aniline oil has not been so satisfactory for the reason that in the beginning they had no protection in the way of duty and were compelled to compete on an even basis with Europe, which could not be done successfully. They did, however, succeed in securing a duty of 10 per cent under the present tariff, which went into effect in October, 1913, just a year ago, but unfortunately this did not avail them anything in the beginning for the reason that the convention which controls the production of aniline oil in Europe immediately reduced their prices 10 per cent, to effect this duty so that we were no better off here than before. This is a sample of what is called unfair competition on the part of European firms in their attempt to prevent the increase of the aniline industry in this country, but could be readily checked if our Government would incorporate in their tariff what is known as the "dumping" clause, which is a clause forbidding the importation into and the selling in the United States of any products at a less price than they are sold in the country of production.

In spite of this check, however, the American manufacturers will continue the manufacture of oil, hoping that conditions will change in the near future so that they may be able to do so at a profit, and when this object is attained their plans are then to take up the manufacture of other intermediate products until everything necessary is finally manufactured here. As a matter of further interest, I might say that our own factory in Buffalo made aniline oil thirty years ago, but were obliged to give up its manufacture at that time owing to their inability to secure benzol. This situation is, however, now changed, as sufficient benzol should be obtained to continue the manufacture under advantageous conditions.

The other exception to my statement that these intermediate products are not manufactured here is nitro-benzol, known also as crude oil myrbane, which is in some demand from outside industries as well as the aniline industry, but not to so large an extent as aniline oil, and which is made here from time to time as conditions warrant; in other words, when it can be made at a profit in competition with Europe.

There is another demand springing up for these intermediate products, which may increase their consumption to such an extent that there will be a large demand entirely outside of the aniline industry, for instance, in the manufacture of smokeless powder and other explosives. The manufacturers of these are now using such products as diphenylamine, tri-nitrotoluole, nitro-benzol, pyridine, nitro-naphthalene, etc., and will finally create a demand which will necessitate their manufacture in this country as a matter of safety. For if the Government depended on explosives made from these materials it will in self-defence have to create some sort of subsidy or tariff protection, making it possible for their manufacture irrespective of European competition.

This is also true, by the way, of carbolic acid, which is a primary coal-tar product, and which is used in the manufacture of picric acid, an explosive product used by the Government. Carbolic acid is not being manufactured here at present to any extent and is now being practically unobtainable from Germany or England by reason of these countries having placed an embargo on this product.

From these so-called intermediate products we then come to the manufacture of the actual aniline dyes as sold in commerce, and their number is voluminous and complex. My good friend Dr. Hesse, for instance, recently stated in a published letter that there were some nine hundred different manufactured products, most of them as different each from the other as a pair of shoes is from a pair of socks. Of these nine hundred he observed that some seventy-six are now made in this country, but that this number is apparently not sufficient to meet the users' demand. In this statement I am quite ready to agree with him, except that we now make nearly one hundred types, which is more than he gives us credit for making. I will say, however, that of these nine hundred original types a great many are obsolete and probably we could get along quite well with a much less number, but as the one hundred made in America are all live types and those which can be manufactured regularly, you will see we are making really a much larger percentage of the total than is apparent at first glance.

In fact, I might almost venture the statement that with the hundred or so types already manufactured here, together with perhaps a few more which we would be prepared to take up on short notice, we would be able to furnish the American consumer perhaps 90 per cent of their color demand, speaking now of types or shades and not of quantity. The other 10 per cent which we could not furnish are such products as alizarines, indigo and patented specialties which would require large installations which would take a long time to complete.

It would perhaps be interesting in connection with these colors to give a hasty sketch of their beginning and development until the present time when they have resulted in the great chemical industry of Germany, the investment of millions of dollars and the employment of thousands of people.

The first color discovered was mauve, which is a sort of violet, by Perkin, in 1856. Then followed magenta and fuchsine in the same year, and a small establishment for the manufacture of same in England, which was not, however, very successful. Then came in 1862 the discovery of soluble or water blues, then the discovery of Hofmann's violet about 1863, Bismarck brown in 1863, then naphthol or martius yellow in 1864, nigrosines in 1867.

It was about this period that the Germans became actively interested in these products, and commenced their patient, intelligent and careful researches into the subject, which later resulted in the most wonderful discoveries and the development of this industry in their country.

Then followed the discovery of orange, fast red, chrysoidine, malachite green, ponceau (scarlet), methylene blue, eosines, and metanil yellow about the years 1875, 1876, 1877 and 1878, and the manufacture then became one of recognized merit and importance.

After 1880 followed in rapid succession the discoveries of auramine in 1883, tartarzine in 1884, benzo purpurine in 1884, congo red in 1885, benzo azurine in 1885, naphthol black in 1885, diamine red in 1886, rhodamine in 1887, to mention only a few of the best known and most successful colors.

From 1880 to 1890 might be called the golden period of the business. Just prior to that time alizarine had been discovered, red in 1871, blue in 1877, patented, and successfully produced and sold at high prices with correspondingly large profits, and it was about that time that our German friends discovered the advantage of securing an exclusive market in the United States through their patents, which enable them to sell at high prices here although continuing the manufacture in Germany. The profits from such patented products as alizarine, benzo purpurine, diamine red and other direct dyeing cotton colors, auramine, rhodamine, tartrazine, and other such colors which were discovered and put on the market in that period, were enormous and put the German industry immediately on such a high pinnacle of success that it has continued until the present time.

In the nineties came the discovery of such important products as direct blacks for cotton and acid and chrome blacks for wool, the total consumption of these blacks being much larger than all the other colors combined.

It was also at this same period that began the first of the patents on synthetic indigo, of which there are many, and which was finally put on the market at such a tremendous expenditure that it has only been a commercial success in the past few years, finally being such a success that it has replaced the natural indigo practically altogether.

I might say in connection with the development of colors, that in the nineties came also the development of such pharmaceutical products as phenacetine, antipyrin, etc., which paid enormous profits to the manufacturers and which were also controlled by patents.

Such, then, is the wonderful development of the coal tar industry, there being invested at this time in Germany something like four hundred millions of dollars (probably more) and the employment of some fifty thousand people in factories, paying dividends to their stockholders, some of them 25 to 30 per cent, and that after charging off a third of their profits to sinking funds for the erection of new plants and for other such purposes. In fact, this has been done for so long a period that most of the present property and plants do not appear on their books at all as an asset, but have been built from the surplus profits. This statement is made on the basis of balance sheets for 1913 issued by one of the great factories, this factory having a capital of 55 million marks ($13,750,000), but whose stock is selling for over six times par value, showing that the actual capital in the business was at least four times the shares issued, or some 200 million marks ($50,000,000). On a capitalization of 55 million marks they showed a profit of 25 million, or nearly 50 per cent, one-third of which was written off for their real estate and plant account, leaving about 16 million marks from which they paid a dividend of 28 per cent.

Assuming that I am correct in my estimate of some

400 million dollars being invested in the industry in Germany, and assuming that a fair proportion of their production is shipped to the United States, it would mean that if the United States were to develop this industry to take care of all their consumption here they would need millions of dollars and would need to employ thousands of people. This will give you an idea of the magnitude of the business that it is now proposed that we establish here to its full extent.

It might be interesting at this point to give you the amount of aniline products imported into the United States from these European factories, the figures being for 1913: Aniline dyes, about $7,000,000; Indigo, about $1,000,0000; alizarines, about $1,500,000, a total of about $9,500,000. These figures are, however, cost prices, and when the American duty of 30 per cent is added on aniline dyes, and further amounts are added for expenses and profits on their sale here it means that the American consumers are really paying something like $12,000,000 for their supplies, not counting the colors produced in America, which may perhaps reach about $2,000,000 more, the production in America, by the way, being some 15 to 20 per cent of the total consumption. These figures do not include the importation of pharmaceutical products which are made from coal tar, this being in itself a large business.

Our German friends are entitled to all the benefits which have accrued to them by reason of their shrewd, intelligent and careful attention to this industry, but with such a statement as the above, does it not seem as if they had had enough and it is now time for the United States to participate in this great industry when they are so well prepared to do so by having as good, if not better, natural sources than has Germany, and being consumers of so large a proportion of the German products? We must admit at once, however, that the United States cannot compete with the German manufacturers under normal conditions, first because they have a great advantage in capital, experience, and the general advantage of everything that goes with a successful and enormous business; and second, because the actual expenses of producing in Germany through labor conditions and so forth are much less than in this country, so that some way must be devised that the United States can be put on a competing basis. This can only be done in two ways:

First, by a sufficient protective tariff, which does not necessarily mean, by the way, that this will increase prices to consumers, although many people seem to be of this opinion. For instance, in an article in the *Scientific American* of September 26 they fall into this common error in stating that with an average importation of about $6,000,000 worth of coal-tar dyes in the last thirty years we have a total importation of $180,000,000 during that period, and assuming that duties had been 10 per cent higher than was actually the case this means that a total of $18,000,000 would have been paid as an insurance premium against the possible event of the war such as that which is now distressing commerce. In other words, they mean that the American consumers would have had to pay this large amount of money more if there had been a 10 per cent higher tariff than they had been paying under the various tariffs which had been in effect during that time.

Even if the *Scientific American* were correct in their statement that $18,000,000 would have been paid as an insurance premium in thirty years, this would really be cheap insurance compared to the enormous value of the goods manufactured in which the colors were used, assuming the colors with which to manufacture these goods could not be obtained in the necessary quantities either from Europe or by an increase in the American manufacture. When I speak of goods in which aniline dyes are used I mean a whole range such as textiles, leather, paper, silk, paints and the hundred and one other manufactured products in which the use of aniline dyes is necessary.

In my opinion, however, based on experience, just the contrary to the *Scientific American* opinion is true, for the reason that a higher tariff would have stimulated production and competition and competition always controls the price, and this is shown clearly by actual facts. For instance, on indigo and alizarine colors there is no duty, and as a consequence they are not made here. Theoretically, therefore, they should be sold very cheap, but as a matter of fact by reason of no competition here they are controlled by conventions in Europe which make a uniform price and consumers are, therefore, unquestionably paying more than they would have to pay if such products were made here in competition. On the other hand, take, for instance, direct cotton black, which is an aniline dye which has a protective duty of 30 per cent, and which is made in this country in large quantities, and on which the Europeans have been obliged to reduce their selling price in this country to less than they sell for in Europe, so that American consumers are enjoying prices as low as 17 to 18 cents for a color which sells at from 22 cents and upwards in Europe under normal conditions.

Does any one believe that the low prices would have been made in this country were it not for the competition here, and does it not therefore prove that competition here regulates the price and that it is not so much a question of duty? What the American manufacturers want is not so much a high duty as it is that they want enough to equalize the difference in manufacturing conditions between this country and Europe and protection against the so-called unfair competition referred to in my remarks in connection with aniline oil; in other words, the inclusion of the so-called "dumping" clause. With a proper tariff on these lines the business could be successfully developed.

I might say further that if we could get our intermediate materials at the same prices which are paid by the Germans, and then secure for our colors the same prices obtained by the Germans for finished colors in other countries, plus the actual American duty, the problem would be solved, as this actual American duty if sufficient would then cover our extra cost of manufacturing, and put us in the exact position as are the Germans as far as our selling prices are concerned.

Secondly, as to the modification of our patent laws, so that they would require the manufacture in the United States of all such articles for which patents are issued. England has within the past few years made such changes in her patent laws, and as for Germany, she has always required the manufacture of patented products in her own country. Her present law reads in general that the owner of a patent must work the invention to an adequate extent in this country (Germany) or at all events do all that is necessary to secure such working, and if he does not, then if the public interest is such that the granting of permission to others to use the invention appears needful, it is granted by making some arrangement with the owner of the patent so that he received adequate compensation, but the manufacture of the product itself is insured for Germany.

About 1909 a similar clause was threatened in the patent laws of this country, and to head off such action Germany negotiated a treaty with the United States by which the German working clause was made inoperative on American inventions. In other words, in return for the United States allowing Germany to continue to manufacture her products in Germany and export them to the United States, the United States was allowed a similar latitude in exporting her patented products into Germany. Whether or not the financial results of this treaty were beneficial to the United States is a question, but it certainly did not work out to the benefit of the United States as far as coal tar products are concerned.

In what I have already termed the golden period of the industry, viz., from 1880 onward, there was from 1880 to 1883 a duty of 35 per cent ad valorem and 50 cents per lb. specific, which gave ample protection to the industry, and as a consequence there were nine or ten factories in the United States, and the prospect of becoming independent of other nations for our supply of these aniline products was bright indeed, but the passage of the Tariff Act of July 1, 1883, which abolished the specific duty of 50 cents per lb., leaving only the ad valorem duty of 35 per cent and fixing a 20 per cent duty on the intermediate products, which left only a net protection of 15 per cent, immediately checked the industry here. No new factories were started, and within one year after the new tariff took effect five of those already established were forced to succumb and go out of business, leaving only four to continue the work. Those four would have gladly followed their example but had invested large sums of money in plants which would be an entire loss if abandoned. So they decided to continue to operate their factories, hoping for more favorable legislation in the future, but thus far they have always been bitterly disappointed. No tariff since that time has given them sufficient protection to develop the business to any large extent. Of course, a specific duty of 50 cents in those days was not abnormal, as the selling prices of the colors were so much higher than at present, and if a proper duty had been continued it would have had the same beneficial effect, but the abandonment of a sufficient duty has left open the admission of colors on a basis which really gives no protection at all.

In addition to the first or protective question as a stimulant to the creation of this industry in America, and coming to the second reason—the patent situation—if the Government had in the same golden period, viz., the eighties, required the manufacture in this country of all products for which they issued patents, then it would have at once created a large industry here. The European patentees would have been forced to build factories here to make these products. This means it would have resulted in branches of the European factories in this country, which would undoubtedly have developed into other products even though they might have originally only been erected for the manufacture of patented articles. While this would not have helped the then American factories it would at the same time have inevitably created a large industry here with beneficent results to the country at large.

As I have stated, there are now four factories in the United States manufacturing aniline dyes, our own factory having been established in 1879. While of slow development, at the same time it has been successful to the extent that it has kept in business and now manufactures practically all of the seventy-six different colors mentioned by Dr. Hesse, or, to be correct, the one hundred, to which I referred in the beginning of my remarks, these colors being all of the original colors, such as Bismarck brown, magenta, chrysoidine, fast red, water or soluble blues, eosines, nigrosines, a comprehensive line of direct dyeing cotton colors, and a comprehensive line of acid and chrome colors for wool and silk. This could easily be extended to the manufacture of practically all of the necessary colors now demanded, and which are not covered by patents, so giving the consumer a large variety to choose from, and insuring practical independence of Europe under any conditions. This would be a large business in itself, except by comparison with the great German factories which stand alone in their magnitude.

All of the American factories will continue to manufacture colors to the best of their ability, but they cannot promise any extensive increase in their production without the support of the Government in the line of tariff protection, and incidentally, the change in the patent laws. The latter, however, is not now quite so important as to colors for the reason that many of the original patents have expired and we are free to manufacture a large line of colors provided it is made commercially possible for us to do so, we having already demonstrated our ability to do so as far as experience and willingness are concerned.

I might mention, as far as our own factory in Buffalo is concerned, which by the way, is widely known as the "Schoellkopf Aniline Works," we were the pioneers in the manufacture of such products as nitrobenzol, nitro-toluole, binitro-toluole, binitro-benzol, aniline oil, aniline salts, dimethyl-aniline, and quite a range of sulfo-acids, some of them of our own invention, which are necessary for the manufacture of both acid and direct colors.

We have also made such products as pure carbolic acid and pure naphthaline, but were obliged to give them up as well as the others because we could not compete with the European manufacturers, but we are now hoping that they can again be taken up either by us or by possible manufacturers of intermediate products, and the manufacture continued successfully in this country.

Under the present abnormal conditions our factory is again making some of these products in order to keep in operation as just at present it is not a question of price, but of ability to manufacture aniline dyes almost no matter at what cost, such is the demand. But, whenever conditions become more normal again, then we will necessarily have to give up the manufacture of these intermediate products for the same reasons that we have had to give them up before, viz., that we can purchase them in Europe at lower prices than they can be manufactured here.

I might mention further that our factories in Buffalo are still controlled and directed by Mr. J. F. Schoellkopf, who originally established them, being assisted a little later by his brother, Mr. C. P. Hugo Schoellkopf, so that they have had nearly thirty-five years of continuous experience in the manufacture of aniline products, and are fully competent to continue the manufacture in a large way should conditions develop so they can be increased.

This paper is not intended to appeal for sympathy or help from the Government or from American consumers. We happen to be so placed for the past few years that we could not develop our business as it might have been developed under different conditions. The American factories even as they are, are prosperous, and quite able to take care of themselves up to a certain point. But this paper is intended to show that the business cannot be extended to large proportions for the protection of American consumers, unless with Government help as to tariff and patent laws, as well as the assistance of the consumers themselves, which means giving the American manufacturers the preference wherever they can do so and assisting them to secure the necessary help from the Government.

Here then is a superficial history of the progress of the aniline industry from its inception to the present time, not only in this country but in Europe, and the situation as related to the present and future manufacture of these products in the United States fully explained. Will the United States Government continue its indifferent policy of practically allowing this important industry to drift along as heretofore, or will it now wake up and seize the opportunity to make itself independent of all other nations in its supply of coal-tar products not only for aniline dyes for commercial purposes, but also for pharmaceutical products which relieve illness and pertain to the health of its inhabitants, and for products for the manufacture of explosives which would be absolutely vital in case of war. The future alone can answer these questions.[*]

## The Situation in the Chemical and Dyestuff Industry

The first regular meeting of the New York section of the American Chemical Society was held on the evening of October 9, the general subject of the evening being a conference on chemicals and dyestuffs.

Prof. Allen Rogers, the chairman of the section, referred in his introductory remarks to the European war and the changes which have taken place in the dyestuff industry. He discussed concisely the most salient points to be considered—some 14 points in all.

Dr. J. Merritt Matthews followed with a paper on dyestuffs in the textile industries. He gave a review of the use of dyestuffs and various dyestuff materials—dyewoods, cochinel, and asked and discussed at length the question: Why do we dye our clothes? He then took up the relative merits of aniline dyes versus vegetable and animal dyes. Aniline dyes are uniform, exactly reproducible, and free from foreign materials. Dyewood dyes are not so; 78 different dyes are used in the United States. Dr. Matthews discussed wool dyeing, cotton dyeing, silk dyeing, mordants, and outlined the remarkable career of alizarine dyes.

Mr. Arthur Brill, editor of the *Daily Trade Record*, Millman's Section, followed with a paper on the campaign for the American dyestuff industry. The *Trade Record* tried to help the American dye manufacturers and textile mills, but met with much opposition. There was a remarkable fear on the part of many of the manufacturers to tell the public the actual state of affairs. They preferred to advertise: "Our textile goods will not lack in quality on account of poor dyes. We have large quantities of the best imported dyes." Accordingly this bluff puzzled dye manufacturers. It is high time that people ought to get together and frankly admit actual facts. Textile mills complained to the *Trade Record* that any frank acknowledgement of the state of affairs would reduce and has reduced sales.

Mr. I. F. Stone, president of the National Aniline and Chemical Company, followed with a paper on coal tar colors in America. On account of Mr. Stone's position in the industry and the authoritiative character of his paper, we print his paper in full on page 679.

The last paper of the evening was presented by Mr. Alfred L. Lustig (chairman of the Dyestuff Committee, National Association of Finishers of Textile Cotton Fabrics): Needs of the textile industry.

He spoke briefly on various points, especially tariff regulation, and emphasized that it was very often plain prejudice if the quality of dyes made in the United States was not considered equal to German dyes.

The attendance was very large, every seat in Rumford Hall being taken. A lively discussion was probably expected by many, but did not materialize. The discussion was short.

To sum up concisely the gist of the discussion of the evening:—The United States makes a limited quantity of dyes and small numbers of shades. There is a general uncertainty as to the duration of the war, as to new tariff legislation, etc. This holds back new undertakings. Americans refrain from enlarging their plants and introducing new processes, until a certain amount of assurance can be given that the enlarged industry will be protected in some way or other. There is no doubt that the aniline dyes are much better than dyewood products.

## Chemistry in Lighting

The first meeting of the season of the New York section of the American Electrochemical Society, of which Dr. Colin G. Fink, of the General Electric Lamp Works, Harrison, N. J., is the chairman, will be held at the Chemists' Club, 50 East Forty-first Street, New York City, November 10, 1914. The meeting will be held by the New York section of the American Electrochemical Society with the co-operation of the American Gas Institute and the New York section of the Illuminating Engineering Society. The general subject of the evening will be the effect of chemical research on lighting.

A most interesting program has been prepared, as follows:

Dr. C. G. Fink:—Introductory remarks.

Professor M. C. Whitaker (of Columbia University, New York):—Improvements in the incandescent mantle.

Dr. William C. Moore (National Carbon Co., Cleveland):—Chemistry in the development and operation of flaming-arc lamps.

Dr. R. E. Meyers (Westinghouse Lamp Company, Bloomfield, N. J.):—The new tungsten lamps.

Mr. R. D. Bailey (Cooper-Hewitt Electric Company, Hoboken, N. J.):—The quartz-tube mercury-vapor lamp and its applications in chemistry.

Mr. D. McFarlan Moore (General Electric Company, Harrison, N. J.):—The new Moore tube lamps and the neon tube lamps.

Dr. Herbert E. Ives (United Gas Improvement Company, Philadelphia, Pa.):—The light of the future.

**Arizona Copper Co.** has reduced its production of copper in common with most other western producers. The output for August was 1869 tons of copper, but the September production will be lower.

**Link-Belt Locomotive Cranes** is the title of bulletin 158, just issued by the Link-Belt Company, of Chicago, Philadelphia and Indianapolis. The numerous excellent illustrations show the very large extent to which locomotive cranes are now used in the art of handling materials in the most varied industries. In the one machine is combined a portable hoisting engine, swinging derrick, grab bucket unloader and switch engine. The photographs from practice in various prominent fuel and iron and steel plants are particularly interesting. The chemical industries are represented by illustrations of locomotive crane practice of the Solvay Process Company, the Michigan Alkali Company and various sugar plants.

---

[*] *Addendum.*—After reading this paper, in reply to a question as to whether or not any original work had been done by the American dye manufacturers, that is, whether they had discovered any new products, Mr. Stone stated that sixteen patents had been taken out by the Schoellkopf Works between 1884 and 1903, comprising colors and intermediate products. One of these products, known as Schoellkopf acid, had been taken up by one of the largest German manufacturers and used extensively by them. Another product, direct black, had been taken up by another large German factory and also made extensively by them. Both products were used, of course, through arrangements with the Schoellkopf Works. So the question could be answered in the affirmative.

# The Gas from Blast Furnaces, Its Cleaning and Utilization

BY J. E. JOHNSON, JR.

The realization of the great heating value of the top gases of the blast furnace was very slow in taking useful shape. For centuries, furnaces ran with their tops wide open, discharging the gas into the air, with which it united in a great column of flame, visible for miles by night, even in the smaller furnaces of that early day.

Even after the invention of the steam engine, the possibilities of blowing furnaces by steam power were not practically realized for several decades and furnaces continued to be located primarily with reference to a suitable water power for blowing. In the same way after the invention of the hot-blast in the third decade of the nineteenth century the stoves were not at first heated by gas from the furnace, but were independently fired with coal.

Later a small chamber filled with iron pipes was built over the top of the furnace and the flame from the open top passed up through this, heating the blast which passed through the pipes. Still later flues were built into the brick work near the top, but just below the stock line and connected with a powerful chimney whose base was approximately level with the top of the furnace, this chimney drew some of the gas from the furnace, naturally much mixed with air drawn in from above, and the mixture burnt on its passage from the furnace top through the boilers and stoves to the chimney.

The final step was taken by closing the top of the furnace with a huge conical valve called the "bell" and forcing the gas by the pressure from below out through the flues into a pipe leading down to the ground level, where the stoves, boilers and stacks were located. This pipe early received and still retains the name of the "down-comer."

These top gases in Lake ore practice contain about 50 per cent of the total thermal value of the fuel charged. In districts where leaner ores are used and more fuel is consequently required per ton of iron the gas is correspondingly richer and contains a proportionately larger percentage of the thermal value of the fuel. In Lake ore practice an average analysis is about as follows: carbon monoxide 25½ per cent, hydrogen 3 per cent, carbon dioxide 12½ per cent, nitrogen 59 per cent. The thermal value comes entirely from the two former components.

The hydrogen comes partly from the moisture in the blast which is dissociated in the hearth, and partly from the moisture of the charge which is decomposed in the upper levels of the furnace. This gas under standard conditions of 32 deg. F. and 30 inches of mercury contains from 94 to 102 B.t.u. per cubic foot and has a specific heat of about 0.02 per cubic foot so that it contains about 2 B.t.u. of sensible heat for each 100 deg. F. above that temperature.

This gas is then somewhat more than half as high in heating value per cubic foot as ordinary producer gas. This with the enormous volume produced (some 140,000 cu. ft. per ton of iron in good practice and more where the practice is poorer) give it enormous commercial value, so great in fact as to equal a considerable percentage of that of the pig-iron itself.

This gas having been in intimate contact with the charge in its course up through the furnace, and having carried off all the moisture of the charge not dissociated, necessarily contains much moisture and picks up much fine dust from all the different components of the charge. It also carries a fume consisting of solids volatilized in the hearth of the furnace which sublime into the solid state, but in the form of an impalpable powder, as the gas cools in its progress toward the furnace top.

It is this fume that gives the gas its characteristic appearance, so that an experienced furnaceman can tell more quickly by looking at the gas discharging from the boiler and stove stacks than by any other way if his furnace is working "hot" or "cold," since a relatively few degrees drop in hearth temperature make a great difference in the amount and appearance of the fume thrown off.

The composition of this fume will be treated more at length in a subsequent article; for the present it is only necessary to say that it consists mainly of silica, alumina, lime, potash from the ash of the coke, and iron, and in case the charge contains much manganese, this element is present in the fume to a great extent, changing the white color of the fume of a good working furnace on ordinary iron to a light yellow when running on "spiegel" and to a dark yellow or brown when running on ferromanganese.

In the early days of slow driving the velocity of the gas current through the furnace was small and the quantity of fine ore in the charge was almost negligible in comparison with the quantity of fine ore used to-day, which runs from 50 to 100 per cent Mesabi in the majority of American practice.

Under those conditions a single, comparatively small outlet at one side of the furnace top was sufficient and the quantity of dust carried by the gas was extremely small, therefore a single pipe of moderate size running straight or almost straight down and branching directly off to the stoves and boilers was all that was necessary to handle the gas. This constituted but a small, almost an insignificant fraction of the plant as a whole. Conditions at the present are vastly different from this in three respects:

First, the velocity of the gas through the furnace is several times greater than it was in those early days and the carrying power of the fluid current increases at an enormously rapid rate with an increase in velocity. I have seen the statement that this increase was as the seventh power, which would mean that doubling the velocity would increase the quantity of material carried 128 times. Whether this be true or not it is certain that the rate of increase in carrying power is extremely high.

Second, the ore used instead of being practically all hand-prepared lump consists very largely of fines, much of which is capable of passing through a 100-mesh sieve.

Third, we have come to realize the enormous cost of attempting to utilize gas in its dirty condition for stoves and boilers, even leaving out of consideration gas engines which require gas cleaner than the air we breathe for their successful operation.

These three causes have had an enormous effect on the gas-handling system of the furnace which has in recent years become one of the largest and most conspicuous features of the whole blast furnace plant.

## The Outlets from the Furnace Top

From the time of the closed top or soon thereafter, some furnacemen claimed that the gas should be taken off either from the center of the furnace or at several points symmetrically arranged around the furnace top. Others claimed that the gas, having gone through the stock column, had done its work and that the location of the outlet was a matter of no importance, and that one large outlet located on one side was cheaper and simpler than any other arrangement and just as good.

In connection with furnace tops, I shall show a design of top arranged to take the gas out at the center.

which worked successfully for many years and gave but little trouble. It was, however, impossible to make the top quite so simple in this way as with the outlet on one side, and so the great majority of furnaces built in the United States up to twenty years ago were constructed on the latter plan, although in discussing operation I shall show what is to my mind an indisputable proof that a single side outlet produces an unsymmetrical passage of the gas through the furnace and cannot lead to the best work.

As furnaces and their outputs grew they produced a vastly larger quantity of gas, so their designers provided more gas outlets, two and even up to five or six. Good practice now very generally uses four, though in my judgment three properly located are sufficient.

### Downcomers

This introduction of multiple outlets introduced other difficulties into the design of the plant.

With a single outlet the down-comer could drop almost vertically to the ground close to the base of the furnace, but with this growth of output, necessitating multiple outlets, came the vast increase of dust which I have mentioned and the necessity for providing some means for its removal. As long as the gas traveled on a steep downward slope the dust would accompany it, but when the dust reached the horizontal passages leading to the stoves and boilers and from these to the stack it settled in them and obstructed them so rapidly as to constitute a serious obstacle to continuous and satisfactory operation.

Means therefore had to be provided for the removal of the dust at the foot of the down-comer and for this purpose chambers, at first only a little larger than the gas mains were introduced, but as conditions grew worse and worse these were increased in size and required therefore to be placed further from the furnace in order to give the necessary room for operation.

This threw the foot of the down-comer away from the furnace at its base, while the necessity of reaching more than one outlet threw its top back, from the closest point on the top of the furnace shell, to the center line of the shell when two outlets were used, and finally to the back or opposite side when four or more were used. These two factors flattened the slope of the down-comer from almost vertical to a slope well below 45 deg.

In some of the earlier installations these conditions were made still worse because it was considered necessary to have the down-comer enter the top of the dust-catcher in the center of the latter and this reduced the vertical height at the same time all the other factors above mentioned increased its horizontal reach. I think that the slope of the dust-catcher on some of the plants built about the time of the Duquesne revolution was not more than 30 deg. These were extremely unsatisfactory in operation because not only would dust lodge in them but also coke and other materials from the charge; they did not free themselves under any circumstances and no matter how large they might be built they filled up until the velocity of the gas through them was great enough to scour a passageway through the accumulation on the bottom slope, this of course involving high top pressure and consequent leakage on every joint not tightly sealed.

### Explosion Doors

Down-comers are generally provided with explosion doors for two purposes: First, when furnaces are stopped it is almost impossible to prevent air being drawn into the gas main at some point or other. This air mixes with the gas and produces an explosive mixture. When operation is resumed this mixture is ignited at the boiler or stove burners and an explosion follows which in some cases is violent enough to burst the main, dust-catcher and down-comer unless it is relieved by suitable safety-valves or explosion doors.

Second, the furnace itself is liable to slips or explosions in which a pressure of several pounds to the square inch, ordinarily only occurring at the lower levels of the furnace reaches the top and would do it great damage unless properly relieved.

This later theory has been combatted by Mr. Julian Kennedy who has claimed that explosions were more violent in proportion as they received freer vent; comparing the conditions which arise at such times to those occurring when the cork is removed from a bottle of charged water, if this be done suddenly a great proportion of the contents of the bottle is violently ejected, but if the cork is held back and the gas pressure allowed to pass off slowly none of the contents of the bottle are thrown out. In accordance with this theory the tendency in recent years has been to provide many less explosion-doors than were formerly thought to be necessary, and the results have very largely confirmed the theory, though many furnacemen are not willing to go as far as advocated by Mr. Kennedy and do away with explosion doors entirely.

One design, made about the time of the Duquesne revolution, was intended to be the best possible regardless of expense. Some five or six outlets were provided around the top of the furnace and these were all connected with an annular main, from one or two points on which the branches of the down-comer led off. Explosion doors were arranged on the outside of this annular main, which, of course, was a few feet below the operating platform of the furnace top and in order to provide access to it a supplementary platform was built a few feet below.

This system had almost all of the disadvantages which could be worked into one design. On the side opposite to the down-comer there was so little current of gas that the annular main became sufficiently choked up to make it virtually useless and one or two outlets on the side next to the down-comer carried off all the gas, practically as though the annular main did not exist. On account of the large size and distant location of the dust-catcher and the wide stretch of its branches to reach the opposite sides of the annular gas main the slope of the down-comer was exceedingly flat and it is probable that after it was in operation a short time more than half its area was choked up and not in active use. One of the worst features of the design was the location of the explosion doors which, it will be seen, came just under the main operating platform. Owing to the choked condition of the down-comer the top pressure was high and the explosion doors were generally leaking more or less; if the gas caught fire it burnt underneath the top platform so as to damage the steel work, and if it escaped unburnt the gas came up onto the top platform in sufficient quantity to make it dangerous to stay there any considerable length of time.

It may not be amiss to say a word here as to the general design of explosion doors. These are always made hinged, but are located in two different ways; first, so that the plane of the door is horizontal when closed; second, so that it is steeply inclined or vertical when closed. The latter design is radically wrong and should never be used because the moment of the door due to its weight is little or nothing when it hangs vertical, consequently a slight pressure is sufficient to force it from its seat, but as its moment rapidly increases a much greater pressure is required to force it to open wide as it should when it is needed at all.

The horizontal door works exactly the opposite way exerting its maximum moment when it is closed so that it is very easy to keep tight under ordinary conditions. But when a considerable increase of pressure occurs, forcing the door open to relieve it, the moment of the door decreases as it opens so that it operates more and more easily as it opens wider. This seems at first sight to be an insignificant detail, but as a matter of fact I have seen great annoyances caused by vertical doors, so little gas leaking from them can be objectionable either by burning and damaging the structure or by polluting the air, that the final result is to have a rigid clamp put on the door which virtually destroys its usefulness for its primary purpose even though it may not completely eliminate the leakage.

Fig. 1 shows a design of gas outlets and down-comer which secures practically all the important advantages. The drawing shows the "E" furnace of the Bethlehem Steel Company. The outlets are four in number rising from the conical top of the furnace shell. The down-comer instead of connecting directly with the outlet openings on the furnace shell on the back or high side connects with the outlet pipes at a point several feet above the operating platform and thereby secures sufficient height to give it a slope steep enough to free itself. The explosion doors are placed on the top of these high outlet pipes many feet above the operating platform and if they leak no harm is done. If the gas burns it cannot strike anything to destroy and if it remains unburnt it pollutes the air far above the heads of those who may have occasion to be upon the operating platform.

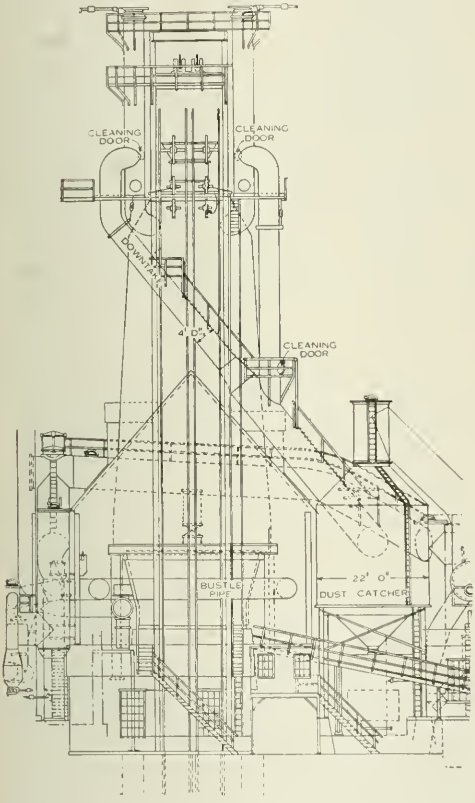


FIG. 1—ELEVATION OF BETHLEHEM STEEL CO.'S FURNACE SHOWING CORRECT DESIGN OF GAS OUTLETS

In the early days the down-comers were made of quite thin pipe entirely unlined and these gave remarkably good service considering the relatively high temperature of the gas they sometimes had to handle, temperatures of 800 or even 1000 deg. F. in regular operation being not uncommon, while, of course, very much higher ones occurred during slips.

In modern practice, however, the down-comer is always built of very substantial steel plate and lined with circle bricks from 3 to 4½ in. thick. This makes an almost indestructible construction but a very heavy one so that due care must be taken to support the weight of the down-comer at both ends. More than one case is on record in which no better support had been provided than the conical top of the dust catcher and this has buckled under the great weight thrown upon it.

### Dust-Catchers

Dust-catchers were not considered a necessary part of a plant until within the last twenty or twenty-five years. The first ones were crudely designed, simply with the idea of providing an enlargement in the gas main in which the velocity of the gas would be reduced and its dust contents dropped to the bottom by this reduction in velocity. Ordinarily very inadequate means were provided to prevent the gas current from picking up again the dust it had once deposited, and the efficiency of the apparatus was in some cases so low that the quantity of dust recovered was inappreciable, and after several years trial the dust-catcher was thrown out and replaced by a plain section of pipe. Evenually the idea took shape of combining centrifugal force with the reduction in velocity to throw out the dust.

The sketch, Fig. 2, illustrates diagrammatically the construction which came to be standard for the first type. Fig. 3 shows an early type sometimes used to secure the centrifugal effect. The tangential inlet into the dust-catcher body constitutes the principal difference in the two types.

The difficulty of preventing the dust from being picked up by the gas current after being once deposited was a serious one and its solution was sought by several furnacemen and several designs were brought out to overcome it by having the dust impinge upon the surface of water to which it would adhere and from which the gas could not pick it up again.

One of the earliest designs to embody this principle was that of Mr. F. E. Bachman, then manager of the Northern Iron Company, at Port Henry, N. Y. Mr. Bachman built a dust-catcher in general appearance not differing greatly from the ordinary type provided with a tangential inlet as shown in Fig. 3. The shell of this instead of being lined with firebrick, as in ordinary constructions, was sprayed inside with a great number of small jets of water which produced a water film running down over this whole interior surface. Centrifugal force threw the gas against this surface to which the dust adhered and was carried to the bottom by the flow of the water film. The gas only being exposed to the surface of the water for a short time did not absorb enough water vapor to affect its thermal value materially. This dust-catcher was in operation for a number of years (as far as known to me it still is) and gave excellent results. The stoves remained clean and serviceable, although the furnace was charged exclusively with magnetic concentrates, which were quite fine.

Another design to secure this result was that of Mr. R. C. Steece, whose dust-catcher is shown by Fig. 4.

The body of the dust-catcher is horizontal and filled with water to about one-third of its height. The gas enters at one end so as to impinge on the surface of the water and is reflected therefrom into a semi-circular passage which brings it back to impinge upon the water a second time. A second semi-circular passage repeats the operation once more and the gas is finally discharged at the far end of the dust-catcher.

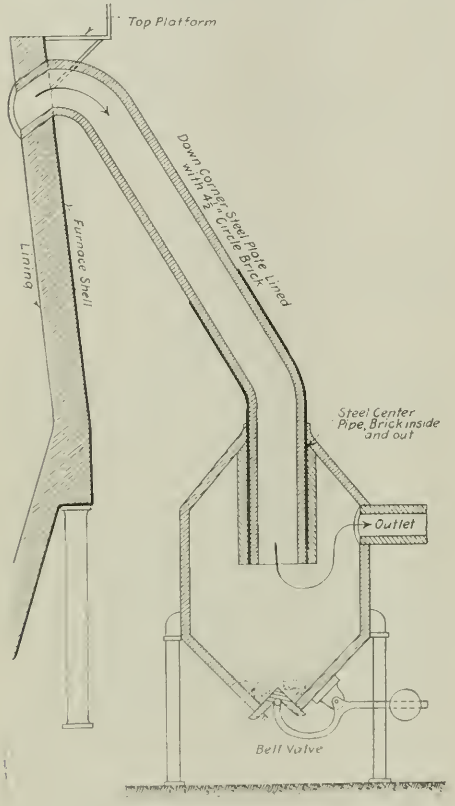

Top Platform
Down Corner, Steel plate Lined with 4½" Circle Brick
Lining
Furnace Shell
Steel Center Pipe, Brick inside and out
Outlet
Bell Valve

FIG. 2—TYPICAL FORM OF EARLY DUST CATCHER

This design avoids the maintenance of the sprays required by the Bachman apparatus, but, on the other hand, the surface of the water is not constantly and rapidly renewed as it is in the Bachman design and this is a point of much importance because when the surface of the water becomes fouled by a heavy layer of dust, other dust impinging upon this is not held but liable to be picked up again and carried on by the gas.

Another dust-catcher which uses the principle of having the gas impinge upon the surface of water is the invention of Mr. B. F. Mullen, of Leetonia, Ohio. This dust-catcher has had the widest appliance of any apparatus of its type. The design is shown in Fig. 4a. The external shape of the apparatus is not unlike that of the standard dust-catcher. The gas enters at the top and passes into the central chamber shown. This chamber is suspended from the dome of the dust-catcher, its shell is lined with firebrick and its bottom constitutes a tube plate supported by the suspension rods *L*. Through the tube plate project a great number of short tubes through which the gas is forced to pass at a considerable velocity. The bottom cone of the apparatus is filled with water to a level from 4 in. to 6 in. below the bottom of the tubes. This level is maintained by overflow through the ports *H* around the circumference of the dust-catcher body.

Fresh water is introduced into the center through the pipe shown and flows regularly outward to the outlet ports *H* through which it discharges. This keeps the surface of the water constantly in motion and prevents its becoming too foul to hold the dirt thrown upon it.

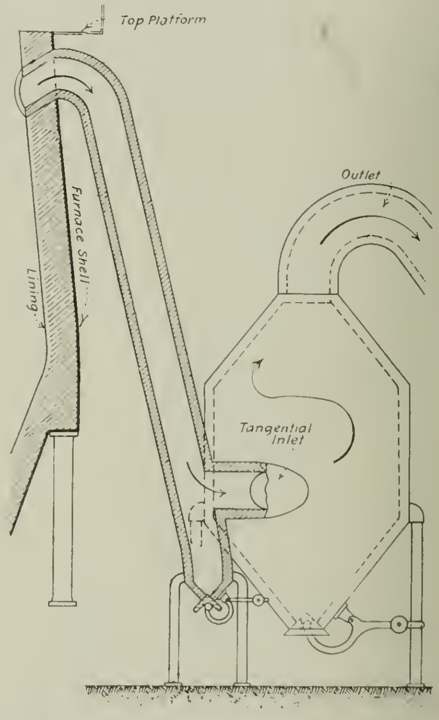


FIG. 3—TYPICAL FORM OF CENTRIFUGAL DUST CATCHER

After the gas leaves the tubes and impinges upon the water surface it passes into the annular space around the central chamber and so to the outlet at the side. The top of the outlet trough just beneath the ports *H* is sealed by a conical plate the bottom of which is riveted to the bottom of the trough, while its top is riveted to the shell of the dust-catcher proper.

The light dust which lodges on the surface of the water is carried away by the flow of the water, while the heavy dust which penetrates the surface is flushed off from time to time through the bell valve at the bottom of the cone. A later design is modified so that the outlet trough for the waste water is inside the main dust-catcher structure instead of outside of it, but the principle remains the same.

This dust-catcher has given very good satisfaction in use. The principal point to be guarded against is any fluctuation of the water level which will permit the end of the discharge nozzles to become wet, because, if they do so the dust will rapidly build upon them and in time they will become completely obstructed. A fact not generally recognized is that flue dust has a very cement-like quality and that when dampened it sets almost as hard as a good cement. This fact has proven the destruction of the number of wet dust-catchers whose designers did not know how to provide against this difficulty.

Through the courtesy of the representative of the Mullen washer I have obtained a copy of the results of a test made on one of these washers by the superintendent of one of the largest blast furnace plants in the country, with a view to finding out if the apparatus were suitable for the conditions at his plant. The results of this test showed that the gas leaving the dust-catcher contained 2.28 grains per cubic foot of dust and after leaving the gas washer it contained 0.75. The representative of the gas washer claims that it is capable of doing considerably better work than this, but even this reduces to a third the total amount of dust carried into the stoves and boilers, as there is a very considerable proportion of the total dust carried through by the stack gases without being deposited, this reduces the proportion which lodges in the stoves and boilers, to their detriment, by a considerably greater percentage, and at the original plant where this washer was installed at Leetonia, Ohio, experience proved that they could run the stoves for the whole blast without taking them off the furnace for cleaning, which would be quite impossible without some means for reducing the dust in the gas far below the percentage which it contains on leaving the dust-catcher.

Many other types of dust-catchers have been built and tried out, but these described give the broad outlines of the art as it existed before the introduction of the gas engine. This forced a further step and a very long one in the direction of cleaning the gas, and as has so often happened, knowledge of the subject gained in learning to clean gas for gas engines has proven of great advantage in directions not contemplated when the work was undertaken. There seem to be definite limits to the degree to which the gas could be cleaned by any type of dust-catcher which depends upon gravity, centrifugal force, or impact upon the water surface or combination of any of these. The degree of cleanness so obtainable is barely sufficient for moderately good practice with the stoves, and as I have previously explained, great economies were effected by cleaning the gas a step beyond this point for use with stoves.

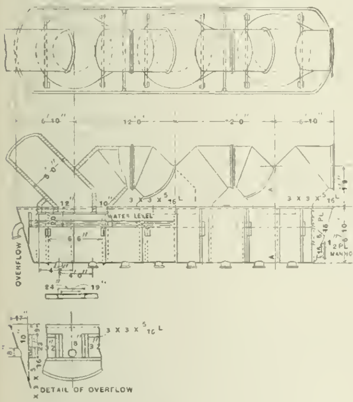


FIG. 4—STEESE AND FORD GAS WASHER

Most of the process used for the next step in cleaning have involved scrubbing the gas with water and this introduced another element in the situation. The gas as scrubbed picks up water vapor enough to saturate itself at the temperature at which it leaves the scrubber and this has a somewhat complicated effect. The gas as it comes from the furnace at a temperature of 300 deg. to 500 deg. carries a very considerable quantity of water vapor picked up from the stock which in a large proportion of modern practice is heavily sprayed with water just before being charged into the furnace. This water vapor is somewhat of a detriment to the gas since it acts as ballast during combustion and prevents attainment of as high a temperature as would be reached with the same gas at the same temperature, dry. By scrubbing the gas with water this temperature is reduced and its saturation point is so much lowered that water may actually be removed from it instead of being imparted by the scrubbing operation.

It is obvious that we have here two conflicting effects. The reduction of the temperature of the gas itself is bad because the sensible heat is an appreciable percentage of the total and if this is removed by any means before gas reaches the burners such removal represents an absolute loss. On the other hand, hot gas can carry an enormous amount of water vapor and this moisture going through the system acts as a damper on the combustion and prevents the temperature from rising as high as it otherwise would. Therefore, to remove the moisture is in itself a benefit.

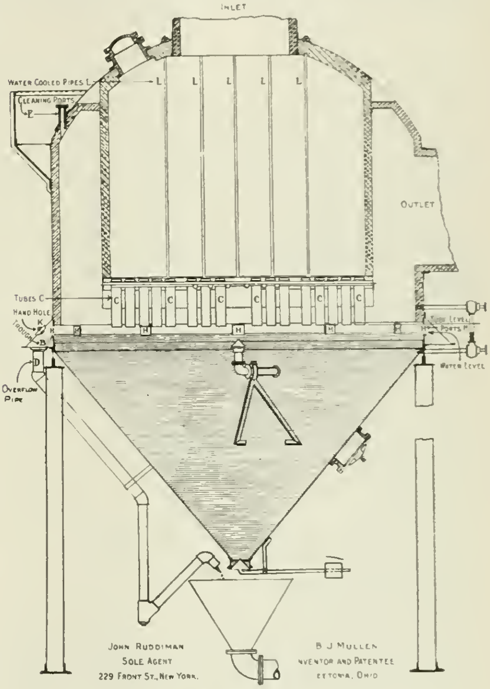


FIG. 4A—MULLEN GAS WASHER

There has been a certain amount of misapprehension on this subject. There have been in recent months two papers on the subject of gas cleaning, of which jointly the value probably exceeds anything published in English previous to that time. These are the papers of Mr. W. A. Forbes, "The Cleaning of the Blast Furnace Gas" before the October, 1913, meeting of the American Institute of Mining Engineers, and that of Mr. A. N. Diehl at the February, 1914, meeting of the same Institute entitled "Data Pertaining to the Gas Cleaning at the Duquesne Blast Furnaces."

From the former of these I shall presently quote extensively and from the latter also to a considerable ex-

TABLE 1.— HEAT AVAILABLE PER POUND OF DRY BLAST-FURNACE GAS UNDER VARIOUS CONDITIONS OF INITIAL TEMPERATURE AND MOISTURE CONTENT. COMBUSTION AIR CONSTANT CONDITION.

| | Washed Blast-Furnace Gas at 70° F. with Moisture Saturated at 70° F. Combustion Air at 70° F. with Moisture Saturated at 57° F. | | | Washed Blast-Furnace Gas at 125° F. with Moisture Saturated at 125° F. Combustion Air at 70° F. with Moisture Saturated at 57° F. | | | Unwashed Blast-Furnace Gas at 400° F. with 35 Grains Moisture per Cu. Ft. Gas at 62° F. and 30 in. Hg. Combustion Air at 70° F. Moisture Saturated 57° F. | | |
|---|---|---|---|---|---|---|---|---|---|
| | Products of Combustion Cooled to 400° F. | Products of Combustion Cooled to 500° F. | Products of Combustion Cooled to 600° F. | Products of Combustion Cooled to 400° F. | Products of Combustion Cooled to 500° F. | Products of Combustion Cooled to 600° F. | Products of Combustion Cooled to 400° F. | Products of Combustion Cooled to 500° F. | Products of Combustion Cooled to 600° F. |
| Total Heat Expended Above 32° F. | | | | | | | | | |
| Fuel Gas. | | | | | | | | | |
| Sensible heat in dry fuel gas, B.t.u..... | 9.128 | 9.128 | 9.128 | 22.449 | 22.449 | 22.449 | 99.61 | 99.61 | 99.61 |
| Sensible and latent heat in moisture, B.t.u. | 16.682 | 16.682 | 16.682 | 94.420 | 94.420 | 94.420 | 81.27 | 81.27 | 81.27 |
| Latent heat of combustion, 1 lb. dry fuel gas, B.t.u. .......................... | 1,253.800 | 1,253.800 | 1,253.800 | 1,253.800 | 1,253.800 | 1,253.800 | 1,253.800 | 1,253.800 | 1,253.800 |
| Total, B.t.u. ...................... | 1,279.610 | 1,279.610 | 1,279.610 | 1,380.669 | 1,380.669 | 1,380.669 | 1,434.68 | 1,434.68 | 1,434.68 |
| Combustion Air. | | | | | | | | | |
| Sensible heat in dry air, B.t.u.......... | 6.292 | 6.292 | 6.292 | 6.292 | 6.292 | 6.292 | 6.292 | 6.292 | 6.292 |
| Sensible and latent heat in moisture, B.t.u. | 7.729 | 7.729 | 7.729 | 7.729 | 7.729 | 7.729 | 7.729 | 7.729 | 7.729 |
| Total, B.t.u. ...................... | 14.021 | 14.021 | 14.021 | 14.021 | 14.021 | 14.021 | 14.021 | 14.021 | 14.021 |
| Total heat expended, B.t.u......... | 1,293.630 | 1,293.630 | 1,293.630 | 1,394.69 | 1.394.69 | 1,394.69 | 1,448.70 | 1,448.70 | 1,448.70 |
| Total Heat in Products of Combustion Above 32° F. | | | | | | | | | |
| Sensible heat in dry products of combustion, B.t.u. .......................... | 144.65 | 183.14 | 228.69 | 144.65 | 183.14 | 228.69 | 144.65 | 183.14 | 228.65 |
| Sensible and latent heat in moisture, B.t.u. | 31.41 | 33.89 | 36.37 | 117.24 | 123.12 | 129.24 | 94.16 | 99.07 | 104.08 |
| Total heat in products of combustion, B.t.u. ...................... | 176.06 | 217.03 | 265.06 | 261.89 | 306.26 | 357.93 | 238.81 | 282.21 | 332.77 |
| Heat Balance. | | | | | | | | | |
| Total heat expended, B.t.u............. | 1,293.630 | 1,293.630 | 1,293.630 | 1,394.69 | 1,394.69 | 1,394.69 | 1,448.70 | 1,448.70 | 1,448.70 |
| Total heat lost in products of combustion, B.t.u. .......................... | 176.06 | 217.03 | 265.06 | 261.89 | 306.26 | 357.93 | 238.81 | 282.21 | 332.77 |
| Total heat available per lb. dry fuel gas consumed, B.t.u. .................. | 1,117.57 | 1,076.60 | 1,028.57 | 1,132.80 | 1,088.43 | 1,036.76 | 1,209.89 | 1,166.49 | 1,115.93 |
| Total heat available per lb. dry fuel gas consumed, per cent.................. | 86.39 | 83.23 | 79.51 | 81.22 | 78.04 | 74.33 | 83.52 | 80.31 | 77.03 |
| Total heat dissipated in products of combustion, per cent.................... | 13.61 | 16.77 | 20.49 | 18.78 | 21.96 | 25.67 | 16.48 | 19.69 | 22.93 |

tent, but both of these in my judgment give an erroneous idea as to the relative importance of removing moisture and of cooling gas. Table 2 of Mr. Diehl's paper is reproduced here as Table 1.

It will be seen that he gives calculations showing the amount of heat obtainable per cubic foot of gas under three conditions.

First—Washed and cooled to 70 deg. Fahr. and saturated at that temperature with water vapor.

Second—Washed and cooled 125 deg. Fahr. and saturated at that temperature.

Third—Unwashed at 400 deg. Fahr. and containing 35 grains of moisture per cubic foot; in other words, its natural condition as it comes from the furnace.

Three temperatures for the escaping products of combustion from the stack 400 deg. Fahr., 500 deg. Fahr. and 600 deg. Fahr., are taken for each of the three cases.

Turning now to the third line from the bottom, "Total heat obtained per pound of dry gas consumed," it will be seen that the amounts in the three cases, all at 500 deg. stack temperature are 1076.6 B.t.u. for the first, 1088.43 for the second and 1166.49 for the third. It is obvious that the most available heat is to be obtained with hot gas in spite of high content of moisture.

Mr. Diehl gives a percentage figure for the three cases in the second line from the bottom of 83.23 per cent, 78.4 per cent and 80.31 per cent. Based on these percentages he states that the dry cold gas gives the highest percentage of available heat.

This is obviously incorrect, as the highest percentage must plainly coincide with the largest absolute amount of heat obtained on any correct basis of figuring. The error has arisen by counting as available the latent heat of vaporization of the water vapor in the gas in all cases. But this is in fact not available under any known conditions of boiler or stove operation since it would require gases to be cooled far below 212 deg. to precipitate much of this moisture and recover its latent heat.

It is obvious that if the burnt gas comes in at 400 deg. and goes out of the stack at 400 deg. no loss whatever has occurred, while if it goes out at 500 deg. or 600 deg., the only loss is that in superheating this small quantity of steam 35 grains, or 0.005 lb., of water vapor, with a specific heat of 0.48 through a range of 100 deg. or 200 deg., making a loss per cubic foot of gas of only a fraction of one thermal unit.

In regard to the effect on the combustion temperature, the results are similar. The quantity of air required for combustion is about equal in weight to the gas itself, therefore the reduction of the initial temperature of the gas by a given amount results in a reduction of the temperature combustion by about one-half of that amount; to cool the gas from 400 deg. Fahr. down to 70 therefore reduces the theoretical combustion temperature by about 160 deg. The removal of the moisture tends to raise the theoretical combustion temperature but quantitatively the amount of increase is smaller than the decrease due to the loss of sensible heat of the gas, about 100 deg. against 160 deg.

When the gas comes from a furnace which does not work a wet burden of ore or wet fuel the conditions become very much worse for wet scrubbing, because in that case there is but little moisture in the gas to be removed by a reduction of the temperature and therefore such reduction represents a net loss both of combustion temperature and of thermal efficiency due to lower combustion temperature.

In the discussion of the paper of Mr. Forbes above mentioned, it was stated by Mr. S. K. Varnes, of the Pennsylvania Steel Company, that at their furnaces they had introduced gas washers for the stoves but that they had been forced to abandon them because of the increased moisture and decreased temperature of the gas which resulted in a decided lowering of the combustion temperature and corresponding reduction of the blast temperature that could be obtained from the stoves. On the other hand, great benefit has been derived from wet scrubbing, where wet ore is used. Thus it will be seen that each case must be handled on its merits. Clean gas is always desirable and undoubtedly much cleaner gas will be used in stoves and boilers than we have been accustomed to in the past, but wet scrubbing should only be adopted after the most careful analysis of the conditions to see whether the net results will be beneficial or not, and if so, to what extent. There is but little use in supplying stoves with clean gas and then finding that we can get from them only lower blast temperatures than we could with dirty gas.

With this introduction I cannot do better than quote extensively from Mr. Forbes' paper as follows:

### DUST CONTENT IN GAS

The gas leaving the usual dust catcher contains an average of from 3 to 4 grains of dust per cubic foot, and its further cleaning is accomplished in one or two principal stages, depending on the ultimate use of the gas; namely, primary cleaning and final cleaning. In primary cleaning, the gas is sufficiently cleaned for economical use in heating hot-blast stoves and for raising steam in boilers; it has been found that the best results are obtained when the dust content of the gas, after cleaning, does not exceed 0.2 grain per cubic foot. In final cleaning, the gas is sufficiently cleaned for use in gas engines, and in this case the best practice has resulted when the dust content of the gas, after cleaning, does not exceed 0.008 grain per cubic foot.

Various systems and methods are employed for accomplishing the desired results. In modern practice, the gas leaving the blast furnace is, in practically all cases, conducted through downcomer mains and then through a dust catcher of large capacity, and in some cases through two such dust catchers in series. A considerable proportion of the heavier dust is deposited at this stage. From the dust catcher the gas passes to the additional cleaning apparatus through gas mains, usually equipped with downtakes and valves for the removal of the deposited dust. The mode of treatment from this point on varies considerably, according to the opinions of the operators as to the respective merits of various systems.

### PRIMARY DRY CLEANING

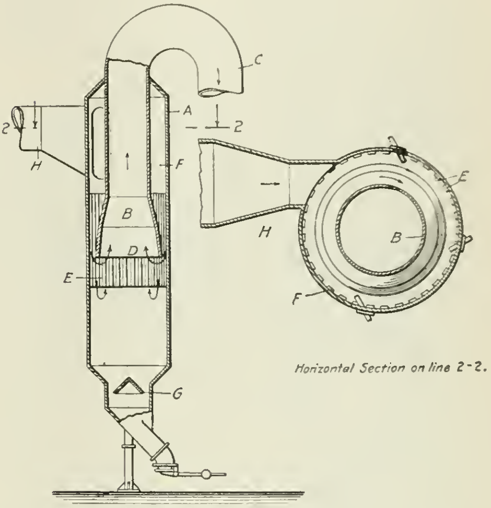
For primary cleaning, a separation of the dust without the use of water—in other words, dry cleaning—has been in favor at many plants on account of the ability to thus conserve the sensible heat of the gas, which is lost when water is used. The fact, however, should not be lost sight of that the benefit derived from the sensible heat of the dry-cleaned gas is largely discounted by the amount of water vapor in the gas. This is especially the case with gas from blast furnaces operating with a high top temperature and using ores and coke containing much moisture existing either free or chemically combined; the water vapor affects the efficiency of the combustion of the gas.

An additional benefit of dry cleaning lies in the greater facility to recover and handle the flue dust in the dry state than in the form of mud or slime in the wet cleaning processes. As before stated, the basic principles in practically all of these dry-cleaning systems depend upon a change in the direction of the gas, a reduction in its velocity, and the separation of the dust by gravity and centrifugal force. The various modifications by which this separation of dust is accomplished are all evolved from the so-called cyclone processes developed in Germany about 20 years ago. Some of these systems recently developed in the United States are the Brassert-Witting, the Roberts, the Kennedy, and the Dyblie. A description of the Brassert-Witting whirler and of the Dyblie whirler will illustrate the general principles of this type of cleaner.

### BRASSERT-WITTING WHIRLER

As shown in Figs. 5 and 6, the Brassert-Witting whirler consists of a vertical outer cylindrical casing, *A*, and an inner inverted tube, *B*, which at its upper end is integral with the gas main *C*, which takes the cleaned gas away from the apparatus. This inverted tube is flared at its lower end, *D*; a number of iron or steel bars, *E*, are fastened vertically around the chamber *F* and extend from a point well above the lower edge of the flared end *D* of the pipe to a point well below the lower edge of this pipe. In the lower part of the chamber *F* is placed a cone, *G*, which allows the separated dust to enter the outlet pipe.

The gas enters the apparatus tangentially through the flue *H* and is given a rotary whirling motion through the annular space between the pipe *B* and the wall of the chamber *A*. On coming in contact with the bars *E* the dust is caught in the channels between these bars and is held in position by the combined action of centrifugal force and friction. As the gas continues to rotate within the annular spaces above mentioned, its velocity is gradually increased by the action of the flared end of the receiving pipe until when it reaches the lower edge of the end its velocity is at a maximum. On passing below this edge, the velocity is constantly decreased, the direction of the gas is changed and it passes upwardly through the flared end of the pipe to the outgoing gas main *C*.



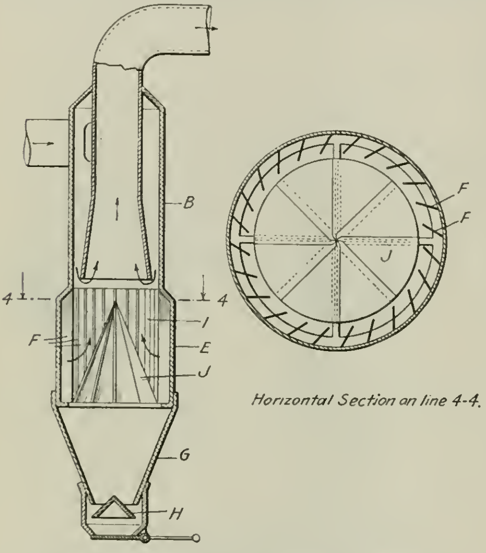
FIGS. 5 AND 6—VERTICAL AND HORIZONTAL SECTIONS OF BRASSERT-WITTING WHIRLER

The dust which has been caught in the channels between the baffle bars drops vertically into the bottom of the chamber, past the cone *G* and into the outlet pipe, whence it is removed as desired.

### BRASSERT MODIFICATIONS OF BRASSERT-WITTING WHIRLER

In the Brassert modifications of the Brassert-Witting whirler, a sketch of which is shown in Fig. 7, the lower portion of *E* of the casing is larger in diameter than the upper portion *B* and is provided with a series of inwardly projecting baffle plates, *F*. The lower portion *G* of the casing *E* is cone-shaped and constitutes the dust-receiving chamber. In the bottom of this chamber is a cone, *H*, whose function is to direct the dust toward the periphery of the dust outlet pipe. Within the chamber *I* another cone, *J*, is located and this cone is provided with a series of baffles, which are arranged as shown in Fig. 8.

In Fig. 9, which is a further modification, a spiral, *L*, is provided for the purpose of directing the flow of the gas. The lower end of the outlet pipe is made barrel-shaped. The outer casing *M* in its lower portion *N* is supplied with the baffles *O*, which instead of being mounted on the casing are bent inwardly therefrom, thus forming the apertures *P* (Fig. 10). The section *N* of the casing is inclosed by an outer casing, *Q*, thus forming the annular chamber *R*, in which partitions *S* are placed to prevent whirling of the gas in this annular chamber.



FIGS. 7 AND 8—VERTICAL AND HORIZONTAL SECTIONS OF BRASSERT MODIFICATION OF BRASSERT-WITTING WHIRLER

The gas is introduced and discharged and the dust is separated in a similar manner to that mentioned in the description of the Brassert-Witting whirler.

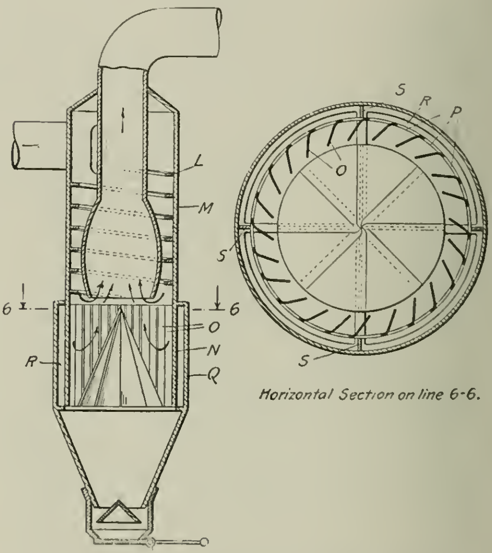
### DYBLIE WHIRLER

In this whirler, as in most of these types, the separation is accomplished by combined centrifugal force and the action of gravity. One of the principal features in this particular whirler is the arrangement in the spiral separator of the entrance and exit openings in substantially the same horizontal plane, obviating the necessity of the gas changing its direction of flow at a sharp angle.

Described in general terms, this separator consists of a spiral conduit, the lower open edges of which connect with the dust-collecting chamber. The gas is introduced tangentially and follows a spiral course toward the central axis of the apparatus, the spiral conduit being increased in area before the gas enters the central chamber, prior to its exit from the apparatus.

The dust is separated from the gas by centrifugal force and gravity, and falls through the lower open edges of the spiral into the dust-collecting chamber. The central chamber is provided with a small opening at its lower end, and connects with the innermost spiral of the spiral conduit.

In the accompanying sketches, Fig. 11 is a vertical section through the Dyblie whirler and Fig. 12 is a horizontal section. The gas enters tangentially from the gas main through the opening *A* in the shell of the casing; the gas impinges upon the first turn of the spiral *B* and follows the turns of the spiral. A separation of dust from the gas occurs through centrifugal force, the particles of greatest specific gravity being thrown outwardly and falling by gravity to the bottom of the casing. At the point *C*, an increased area is provided between the spiral and the central chamber, which causes a decrease in the velocity of the gas, thus allowing a further separation.



FIGS. 9 AND 10—VERTICAL AND HORIZONTAL SECTIONS OF BRASSERT MODIFICATION OF BRASSERT-WITTING WHIRLER

The inlet *A* and the outlet *D* are in substantially the same horizontal plane, and this permits the separated material to drop out of the whirling gas and prevents its being caught up in the vortex, which happens when a sudden change in the direction of the flow of the gas occurs.

A deflector, *E*, located at one edge of the opening, is provided. This is in the shape of a hook, which acts to catch any dust which might be carried into the casing, and this completes the separating operation.

### REMARKS ON EFFICIENCY OF DRY CLEANING

It has been demonstrated in practice that dry cleaning by anyone of the systems so far referred to, cannot be depended upon by itself to continuously clean the gas from blast furnaces using much fine ore, to the degree desired for use in stoves and under boilers, the amount of dust remaining in the gas ranging from 1 to 3 grains per cubic foot, depending on the working of the blast furnace. Such systems have a value, however, in removing, by simple apparatus and at practically no operating expense, a certain proportion of the dust and so decreasing the duty upon any apparatus installed for further cleaning.

The above remarks on dry cleaning refer in no way to the Halberger-Beth system, recently developed in Germany, which will be treated separately later on.

*(To be concluded.)*

# Quantitative Blowpiping as an Aid to the Prospector

BY SIEGFRIED FISCHER, JR.

## Introduction

It has been the writer's pleasure to attend one of the most interesting courses given in a metallurgical department of a university. At Lehigh University, South Bethlehem, Pa., Dr. Jos. W. Richards gives a course on quantitative blowpiping which to my knowledge is unique in this country. Its importance and value struck me at once, as it would be a godsend to the prospector. With some patience and good will the average scientifically educated prospector could become proficient in the manipulation of the operations so that he could save money which he now spends, in many cases uselessly, for having assays made on all materials which to him seem of value. But that is not the only saving.

When one wishes to make his own assays, a portable assaying outfit is necessary. This involves quite an expense and the outfit is not the easiest thing to transport from one place to another. When one realizes that the minimum apparatus necessary to perform an assay by means of a blowpipe analysis can be carried in a cigar box, and that its initial cost is about one-tenth of that of a portable assay equipment one can readily observe that there is a decided gain in its use.

The average prospector desires first of all to know whether or not his ore bears values such as gold and silver. Then if so, whether it is there in sufficient amounts to justify its working. The simplest quantitative blowpipe outfit will tell him that, if he is able to use it. With a more elaborate equipment he is enabled to attain results as close as any assayer. Such metals as gold, silver, copper, cobalt, nickel and mercury can be determined with a high degree of accuracy.

Dr. Richards has devised various means to simplify the work both in apparatus as well as in methods which I will describe in the course of this paper. My main endeavor in this article is to outline the methods used for the most important metals and to bring before mining institutions situated in localities where prospecting for these metals is carried on to-day, a course, which, if given in a summer school, would enable men outside of the institution, interested in prospecting work, to become more proficient in their field. As a course for metallurgical students it has another advantage, namely, that of performing metallurgical operations on a small scale.

With this outfit all work can be handled to show a prospector whether or not the ore he is considering is worthy of closer investigation or not. He can by this means save both money and time, as it always takes several days, and at times weeks and months, before he gets the "returns" from the assayer.

I have seen Dr. Richards complete a gold and silver assay in twenty minutes. Of course, he is an expert in this line of work, but the average working time which I have observed in the class was between one hour and one and one-half hours, the class numbering eight men. I myself have completed Au-AG-Cu assays within this time limit and a speiss containing Fe, Co, Ni, Cu, Au and Ag within two and one-half hours. Mercury ores can be easily finished in 10 minutes.

With a few additions to the equipment mentioned, we may check up our results or obtain greater accuracy. Greater accuracy may at times be attained by weighing theAu and Ag buttons. For this purpose a portable assay balance may be used. This increases the expense of the outfit, but it insures the correctness of the results. Such balances are of greater bulk, but there is no difficulty in devising means for combining these with the rest of the equipment into one unit. Such a balance may be had from one laboratory supply compound at a price of $70.00, being 8½ inch x 5 inch x 9½ inch in case, and having a sensitiveness of 1/100 milligram. Another balance furnished by the same company is the Nixon Portable Assay Balance; size 11 inch x 2 inch x 1 inch; cost, $20.00. Other firms have other makes, probably just as efficient as these.

GENERAL

Simple equipment.

| | | | |
|---|---|---|---|
| 1 | Pocket assay balance | $16.50 | $17.50 |
| 1 | Anvil | | 0.40 |
| 1 | Plattner's blow pipe, with removable platinum tip | | 2.50 |
| 1 | Charcoal borer | | 0.75 |
| | Natural charcoal, per 10 | | 50 |
| 1 | Set porcelain dishes | | 0.35 |
| 1 | Dropping bottle for nitric acid | | 0.15 |
| 1 | Plattner's platinum tipped forceps | | 2.00 |
| 1 | Form for paper cylinders | | 0.15 |
| 1 | Plattner hammer | | 0.60 |
| 1 | Ivory spoon | | 0.25 |
| 1 | Magnet | | 0.10 |
| 1 | Magnifying glass | | 1.50 |
| 1 | Agate mortar with pestle | | 1.70 |
| 1 | Mortar (Diamond Leed's) | | 2.00 |
| 1 | Pliers for buttons | | 0.75 |
| 1 | Plattner's ivory scale | | 3.00 |
| 1 | Alcohol lamp | $0.30- | 0.40 |
| 1 | Scissors | | 0.50 |
| 1 | Cupel holder with 2 molds and 1 stamp | | 1.70 |
| 1 | Test lead measure | | 0.50 |
| 6 | Small test tubes | | 0.12 |
| 1 | Horn scoop, small | | 0.25 |
| 6 | Two ounce wide mouth bottles, Screw capped for chemicals | | 0.25 |
| 1 | Box (wood) for bone ash. | | |
| | Silver foil, per 25 gm. | | 1.25 |
| | Fairly hard melting glass tubing, 8 mm inner diam | | 0.50 |
| 2-6 | Candles | | 0.15 |
| Chemicals: | Boric acid (cryst.), per lb | | 0.25 |
| | Litharge, per lb | | 0.12 |
| | Borax glass (fused), per lb | | 0.40 |
| | Test lead, granulated, free from silver, per lb. | | 0.25 |
| | Sodium bicarbonate, per lb | | 0.18 |

Dr. Richards has devised a scale of alloys of gold and silver. These alloys are based on the percentage of silver in them, and the sample under investigation is compared with the colors of the alloys on the scale, one of which it will match. That will give the per cent of silver in the Au-Ag alloy and the rest is gold. This little button is usually flattened out on the anvil first, between two layers of filter paper to insure a bright surface. The accuracy is not very great, the silver content being given only for 1 per cent at a time and, as with all color comparisons, it depends on every individual's ability to match them. However, in many cases where absolute accuracy is not in question, this scale offers a very rapid and simple means to obtain approximately close results. A scale of this type contains thirty-six samples of gold-silver alloys, containing 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 22, 24, 26, 28, 30, 32, 34, 36, 38, 40, 44, 48, 52, 56, 100 per cent of silver respectively.

Another apparatus of Dr. Richards' is his scale for measuring the buttons and obtaining the gold and silver. Two metal strips are fastened so that they touch at one end and diverge towards the other end. This forms a groove in which the button is rolled and measured. The right metal plate is graduated into 100 equal parts, and the groove is of such width that it gives the diameter of the button measured in one-hundredth of a millimeter. With this scale goes a table worked out by Dr. Richards himself, giving for each of the 100 divisions the weight of the gold button in milligrams, the weight of the silver button in milligrams, the volume of the button, the per cent Ag of the Au-Ag button, and the specific weight corresponding to the alloy. The use of this scale will be elucidated under the gold and silver assay.

With few exceptions, little need be said about the other apparatus in the equipment. However, it will pay to lay some stress on the Plattner ivory scale for the measurement of the gold and silver. It is constructed on the principle that buttons of silver or gold obtained by cupellation vary in size proportionally to their weight, and that these weights are proportional to one another and also proportional to the cubes of the diameters.

One is enabled to measure these diameters between two converging lines.

To get the scale Harkort and Plattner took the silver buttons of an ore, which on a muffle assay and a blowpipe assay showed 3.48 per cent Ag. They determined then the position of the best-formed button, obtained by cupellation, between the two converging lines, and this gave the division designated as 50. Dividing the stretch on the scale from the point at which the two lines meet to the point 50 into fifty equal parts, they obtained the left side of the scale. The convergence for a length of scale of 156 mm should be 0.09 mm. The right-hand figures give the per cent Ag by weight, if 100 mg of material were used for the assay.

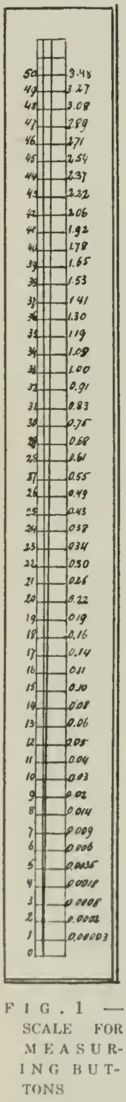


FIG. 1 — SCALE FOR MEASURING BUTTONS

Experience has shown that one can determine the weight of a silver button more accurately on the scale if it lies between 0 per cent and 0.45 per cent than it can be done on a balance. Above 0.45 per cent the balance is more accurate. Fig. 1 shows the Plattner scale.

To use this scale, the button obtained by cupellation is carefully cleaned. Care should be taken not to change its shape by any exertion of pressure, etc. It is then picked up in a pair of forceps, carefully put between the two converging lines and pushed along until both lines are just tangent to the edges of the button. To get correct readings one should use a magnifying glass. Repeated readings should be made. As the button is round great care must be taken in its handling, to prevent it from rolling off the scale and being lost. If the button lies between two of the horizontal divisions, the following should be observed: if it lies approximately half way between the two divisions, the numerical sum of these divided by 2 will give close enough results. If, however, the button is closer to one than the other one must then gauge by the eye.

As already mentioned, the numbers on the left-hand side of the scale give the weight in milligrams, if 1 decigram is used for the assay. If we now remember that there are 29,166 66/100 troy ounces in a ton of 2000 lb., and that in an assay ton = 450.09992 gr. troy there are 29,166 66/100 mg, then we see that if an assay ton were used for an assay, instead of 1 decigram, then each milligram of silver found would represent 1 oz. of metal per ton of ore.

Rule: To convert the milligram readings over into ounces divide the number of grains in an assay ton (450.09992) by the number of grains taken for the assay (where 1 decigram is used by 1.5432 grains); multiply the result by the weight of the button in milligrams according to the Plattner scale and the result is the number of ounces of silver the ore carries to the ton.

Example: Three grains of ore are taken for an assay. The silver button lies on division No. 16 equal to 0.11 mg.

Required: Number of ounces of silver to a ton of ore.

$$(450.09992 \div 3) \times 0.11 = 16.5 = 16\tfrac{1}{2} \text{ oz. of silver per ton.}$$

But not only is the Plattner scale of value for the silver determination, but Plattner himself has worked out the values for gold on the same scale, that is, the milligrams of gold for Division No. 0 to No. 26, which is the limiting division for accuracy. The best results obtained on this scale for gold are between 0 per cent and 0.45 Au.

PLATTNER SCALE FOR GOLD

| Div. No. on the silver scale | % gold |
|---|---|
| 26 | 1.065 |
| 25 | 0.946 |
| 24 | 0.838 |
| 23 | 0.737 |
| 22 | 0.645 |
| 21 | 0.561 |
| 20 | 0.485 |
| 19 | 0.416 |
| 18 | 0.353 |
| 17 | 0.298 |
| 16 | 0.248 |
| 15 | 0.205 |
| 14 | 0.166 |
| 13 | 0.133 |
| 12 | 0.105 |
| 11 | 0.081 |
| 10 | 0.061 |
| 9 | 0.044 |
| 8 | 0.031 |
| 7 | 0.021 |
| 6 | 0.013 |
| 5 | 0.008 |
| 4 | 0.0039 |
| 3 | 0.0016 |
| 2 | 0.0005 |
| 1 | 0.00006 |

Among the working tools of quantitative blowpiping, this scale and Dr. Richards' modification of it are without a doubt the most important ones and the correct manipulation is of paramount importance.

The other utensils may be found in any of the many catalogs of firms handling chemicals and laboratory apparatus and their use is self-evident.

One thing of great importance, which is not named in the equipment given is the soda paper. There is, however, no use spending money for it, as it can be very readily made in the following way: Cut strips of paper about 1 in. wide. Long ordinary bond paper is as good as any, the strips having the length of the sheet. Now prepare a saturated solution of sodium carbonate. Draw each strip through this solution so as to wet both sides along their entire length. Then hang them up to dry. When dry, cut these strips into pieces 1½ in. to 2 in. long and put into a covered box until required for use.

*Operations.* In quantitative blowpiping, the following steps must be observed:

I. Preparation of the ore for assaying.
    1. Grinding of a fair average sample.
    2. Sampling.
II. Weighing out sample.
III. Weighing out fluxes, etc.
IV. Making up the charge and wrapping it in soda paper.
V. Working down to the desired metal or metals. This step varies so much that each special case will be treated in detail under the individual metals.
VI. Determining the weight or percentage of the desired metal or metals.
    This will be taken up under the separate metals.

It will not be out of place here to mention some of the fundamental things. For quantitative work the luminous flame should be used, a flame such as a candle gives. Two kinds of flames may be obtained with this flame by using the blowpipe, the oxidizing and the reducing flame.

The oxidizing flame is obtained by putting the tip of the blowpipe into the flame and blowing rather strongly. The flame will be long, pointed and blue (Fig. 2). The harder the blowing the hotter the flame. The melting point of platinum, 1775 C., may be attained with it.

To produce a good reducing flame is more difficult than to produce a good oxidizing one. It is obtained by holding the tip of the blowpipe just outside of the flame and blowing not too strongly. A good reducing flame should be a long luminous cone, the end of which is faintly blue. The most effective part is between *a* and *d*, and the assay should be totally covered by this part (Fig. 3).

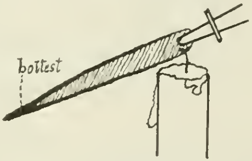


FIG. 2—OXIDIZING FLAME

In general it may be said that an oxidizing flame is used when some undesirable metal is to be slagged off and a reduction flame where it is necessary to collect metal.

As it is necessary to apply a flame steadily for quite a length of time, it is absolutely essential to know how to use the blowpipe correctly. For this purpose, rest the elbow on a table or board of convenient height, raise the forearm until vertical, grasp the stem of the blowpipe firmly with the four fingers, allowing the end nearest the mouthpiece to rest on the thumb, and press the pipe tightly to the lips. The blow should take place without stopping the natural breathing. Take a good breath of air and when the blowpipe is applied to the lips fill the space between the cheeks with air and blow. The cheeks act as bellows. When they are collapsed fill them again without stopping the breathing and continue the blowing. In this way only can a steady flame be applied for any length of time.

*Preparation of the Ore for Assaying.*—One of the most important operations is the correct sampling of the ore. Care must be taken to obtain an absolutely fair average sample of the material to be tested. It is best, of course, if the material has passed through a regular sampler, but as this is not apt to be possible for a prospector, it must be left to him to pick a fair sample.

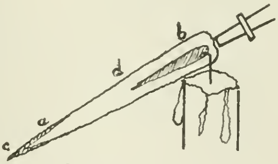


FIG. 3—REDUCING FLAME

A good scheme to follow is to take a representative sample of approximately 1 lb. of the ore, wrap it up in a cloth or several thicknesses of paper, and break it up as finely as possible with a prospecting hammer, on a flat rock, anvil or an iron plate. This done, spread the material out on a sheet of paper so that it forms a circle. With a stick divide this circle into four quadrants Fig. (4). This done, take the two diagonally placed ones (*A* and *D* or *B* and *C*) for further use and discard the rest (*BC* or *AD*). The material retained is again spread out in a circle, quartered and treated as above. Continue this operation until a sample of about 1 oz. is obtained.

This is then finely ground up in the steel mortar, and in the agate mortar until as fine as an ore used for ordinary assay work. At times a couple of sieves of small diameter (one 80-mesh and one 100-mesh) may prove useful. The sample thus obtained is put in a sample bottle and used for the assay.

*The Weighing Out of the Sample and the Fluxes.*—This, outside of the test lead, is done on the balance. Ordinarily 100 mg of sample are very carefully weighed out. If the ore is a very poor one, 200 mg may be used, and if very rich 50 mg. This, however, holds only for silver and gold ores. It is then necessary to make corrections.

For the weighing of the fluxes the accuracy need not be so great, but it pays to be saving in their use. For the test lead a separate device is employed. It consists of a cylindrical piece of wood having a graduation of 5, 10, 15, and 20 on it. These divisions represent 500 mg each, or in the language of the trade 5 Zentner. Over this wooden cylinder fits a glass tube of the same length as the wooden cylinder. All according to high the glass tube is raised one can, by filling the vacant part of the tube measure out 500, 1000, 1500, and 2000 mg of test lead. The weighing out may be done by using the point of a penknife.

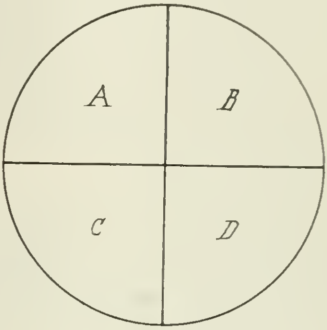


FIG. 4—QUARTERING

*Making Up the Charge and Wrapping in Soda Paper.*—The mixing of the ore and of the fluxes is done in the little horn scoop. The ore and fluxes are put in the scoop, care being taken that all of the weighed ore is removed from the scale pan. Then they are thoroughly mixed with the end of a penknife, and if required are ready to be put in the soda paper.

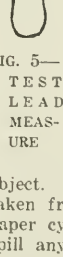


FIG. 5—TEST LEAD MEASURE

The procedure is as follows: One piece of soda paper is wrapped around the cylindrical wooden mold, allowing a piece of the paper to overlap the end of the cylinder. This end is then closed up, as you would wrap the bottom of a round flask, and firmly pressed against some flat, hard object so as to make it stay closed. The paper cylinder thus formed is carefully removed from the mold held lightly between the index finger and the thumb of the left hand, the closed end resting on the table or some flat object. The charge is then carefully taken from the scoop and put into this paper cylinder, care being taken not to spill any. The scoop is finally brushed down into the cylinder with a small camel's hair brush. With the platinum-tipped pliers the open end of the paper cylinder is then folded over several times tightly and finally the corners are turned up to prevent the small package from opening. Its appearance will be as shown in Fig. 6. This then is ready to put on the charcoal for reduction.

FIG. 6—CHARGE IN PAPER CYLINDER

Having discussed the main general features, we will deal with the special features in the next article.

# Coal Gas Residuals*

BY FRED. H. WAGNER

A hundred years of development have passed since Murdoch lighted the city of London with coal gas, and these years have placed gas lighting in the forefront of industrial progress, while the history of these years plainly shows how the proper utilization of by-products can revolutionize the magnitude of an industry. The early years of coal carbonization could depend upon no, or but very little, assistance from by-produce sales in the matter of cheapening the cost of production, and not until the aid of modern chemistry was called in, did the production of residuals make any appreciable change in this condition.

The recovery of residuals is a very important conservation of resources, and it forms one of the principal means of revenue to the coal gas producer, the sale of these residuals reducing the cost of gas production in a degree corresponding to the efficiency of the recovery methods adopted and the market value of the product.

The principal residuals recovered to-day are tar, naphthalene, cyanogen compounds, ammonia, and, in the case of coke oven gas, also benzol by a direct recovery method, and they will be treated in this consecutive order in the following pages; the recovery of benzol is confined almost entirely to the coke-oven plant, where a direct method of recovery is adopted, and to the tar distiller, benzol being one of the most valuable of tar constituents. While the recovery of naphthalene cannot exactly be termed one of profit in a pecuniary sense at present, the removal of a certain portion from the gas is of distinct advantage, and the methods adopted for its removal will, therefore, be given.

The gas produced during the carbonization of coal is a mixture of fixed gases, vapors of various kinds, and, at times, also globules of liquids, which are held in suspension, and are thus carried forward by the gas; these gases and vapors also carry forward some solid carbon in the shape of dust.

The principal fixed gases are hydrogen, $H_2$; methane, $CH_4$, also known as "marsh" gas; ethane, $C_2H_6$; propane, $C_3H_8$; butane, $C_4H_{10}$; ethylene, $C_2H_4$; small amounts of butylene, $C_4H_8$; propylene, $C_3H_6$; acetylene, $C_2H_2$; carbon dioxide, $CO_2$; carbon monoxide, CO; hydrogen sulphide, $H_2S$; nitrogen, N; oxygen, O, and ammonia, $NH_3$; while the principal vapors in the mixture are benzol, $C_6H_6$; toluol, $C_6H_5.CH_3$; xylol, $C_6H_4(CH_3)$ carbon disulphide, $CS_2$, and aqueous vapors. These latter vapors all pertain to substances which become liquid at ordinary temperatures, but the vapors of naphthalene, $C_{10}H_8$, phenols, etc., pertain to substances which become solid at ordinary temperatures, and must, therefore, be subjected to a special treatment.

As will be seen later, some of these constituents are of inestimable value to the coal-gas producer, and consequently the treatment of the gas after it is produced in the carbonizing plant, is of great importance; this treatment should not only consist of a method of cooling the gas, and thus condensing and precipitating the vapors as a fluid, but the method of treatment should be such as to retain in the gas those valuable illuminating constituents which may be lost to a greater or lesser extent in the usual condensing plant.

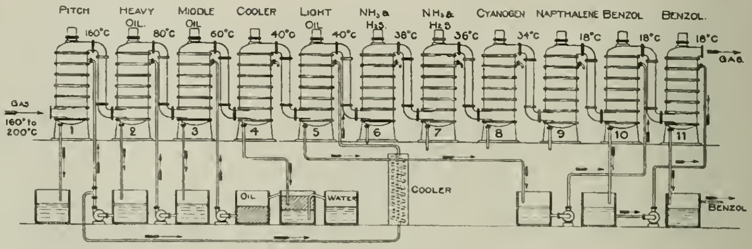


FIG. 1—FEED CONDENSING PLANT

The Feld system of condensation and purification of coal gas, which embraces successive cooling with a fractionation of the products, appears most attractive from the standpoint of efficiency and simplicity.

The usual condensing system in coal-gas practice embraces the use of a primary condenser, exhauster, tar extractor, secondary condenser, and ammonia washer; the tar, together with quite an ammount of illuminants, being thus removed in a greater measure by cooling, while in the Feld system, the gas is not cooled below a point where any volatile hydrocarbons are precipitated or absorbed by the effluent, the tar being fractionated in three washers into pitch, heavy oils, and middle or light oils, and the gas is treated for cyanogen compounds, combined hydrogen sulphide and ammonia, naphthalene, and finally benzol, the entire process being carried out in Feld vertical centrifugal washers, as shown in Fig. 1.

As will be seen from Fig. 1, the entire condensing plant consists of eleven washers, the first or pitch washer operating at a temperature of from 320 deg. to 392 deg. Fahr., the gas being kept at this temperature from the hydraulic main by insulating both the main and the pipe connections, or by the application of external heat, heavy oils from washer (2) being pumped into washer (1) where they are used as the active pitch extracting medium.

Washer (2) removes the heavy oils, and it is operated at a temperature of from 320 deg. to 176 deg. Fahr., all operating temperatures being determined from the actual dew-point of the gas for the constituent to be removed, the extracting medium being the middle oils from washer (3).

Washer (3) removes the middle oils, due to contact between the gas and the oils separated by cooling in washer (4), this cooling being effected by bringing the gas into intimate contact with water, the effluent from washer (4) being run into a separating tank where the oil is separated from the water by specific gravity.

The light oils are removed in washer (5) where the gases are washed by means of heavy oils which are previously cooled in a special cooler, these oils from (5) being run into a reservoir from whence they are pumped into the first benzol washer.

The washers for ammonia and hydrogen sulphide operate under a temperature of from 104 deg. to 97 deg. Fahr. the hydrogen sulphide being combined with the ammonia in these washers with the consequent formation of ammonium sulphate, while the cyanogen washer operates at about 97 deg. to 93 deg. Fahr.

The naphthalene is removed in washer (9) at a temperature of about 65 deg. Fahr., while washers (10) and (11) serve to extract the benzol and its homologues, the partially saturated oil coming from washer (10) being pumped into washer (11).

When this paper was contemplated, it was the desire of the author to treat each residual in a more exhaustive

---

*Paper read before the American Gas Institute. Copyright, 1914, by American Gas Institute. Subject to author's corrections.

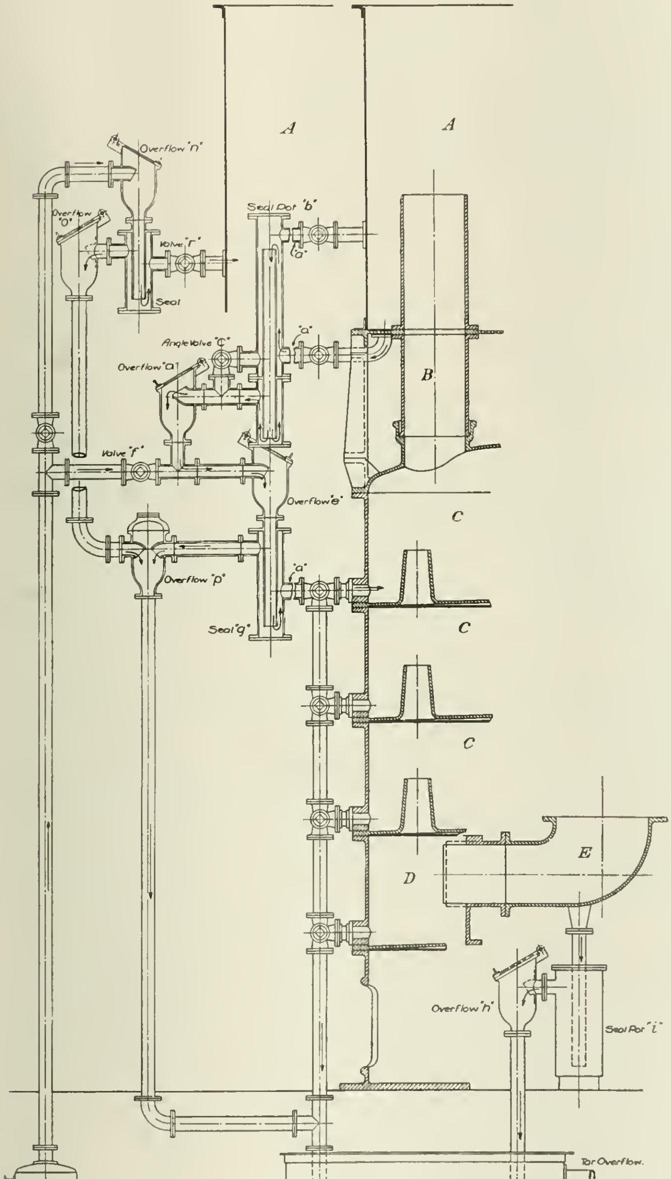


FIG. 2—FELD HOT TAR WASHER

manner, but owing to the large amount of data prepared the contents passed beyond the bounds of a paper of this character, and consequently it became possible to herewith present only the more essential features of residual recovery and the possible profits which might accrue due to the adoption of modern methods of operation.

### Tar

Tar is thick, dark brown, viscid, oily liquid, produced during the dry oscillation of coal; its chemical nature is very complex, and it contains a large number of compounds. The crude gas leaving the retorts is a mixture of permanent gases, but this mixture carries with it quite a number of hydrocarbons and other vapors, and as the illuminating, as well as the calorific, quality of coal gas is, in a great measure, dependent upon its hydrocarbon constituents, it is of prime importance to treat the gas so as to retain as many of these hydrocarbons as is possible. A reduction in temperature, however, soon reduces the hydrocarbons of greater density to liquid form, and this liquid is usually termed "tar." In spite of the fact that the gas temperature at the hydraulic main is perhaps never lower than 145 deg. Fahr., large quantities of tar are deposited at this point, and it is, therefore, almost impossible to retain the hydrocarbons of this class in the gas with the usual method of condensation.

Both the nature of the coal used and the temperature of carbonization exercise a great influence upon the quantity, as well as upon the quality of the tar produced, thus both quantity and quality regulating the amount of revenue received, and in this manner, governing, to a great extent, the final cost of gas production.

In the usual systems as applied at present, the removal, or the precipitation of tar, is accomplished by condensation or cooling; quite an amount of condensation occurs between the retort and the hydraulic main, a further amount of tar being deposited in the hydraulic main proper, after which the gas is conducted to the condensers where gradual cooling further reduces the tar content. After leaving the condensers, the gas still contains quite a number of tar globules in suspension, it being possible to remove only these last traces of tar by means of friction.

In the Feld system, a different method is employed as the heat contained in the gas is utilized by a system of fractional coolings to separate, or wash out of the gas, tar in several of its principal constituents. This treatment may also be varied in such manner as to prevent the formation of tar as much as possible by maintaining the heat of the gas coming from the retorts at a temperature above the dew-point of the gas for the constituents of high boiling points. This may be done by covering the connections from the retorts to the first washer with insulating material, or by applying heat to the exterior of the pipes. The gas thus protected is led to the washers where it is subjected to fractional cooling and successive washings at successively lower temperatures, so that the various tar constituents are separated from each other by employing the temperature of the gas itself, and without the necessity of employing extraneous heat after previous cooling.

A Feld washer especially arranged for hot tar washing is shown in Fig. 2 and in order that aqueous condensation may be avoided in the washer by reducing the temperature of the gas to the dew-point for water, the washing tar should be heated to from 40 deg. to 60 deg. Fahr. above the temperature of the gas at the inlet to the washer, this hot tar being the active tar extracting medium.

In Fig. 2, which shows a portion of a Feld washer with superimposed Pelouze condenser, *A* is a Pelouze condenser; *B*, gas port in washing chamber; *C*, upper washing chamber; *D*, lower washing chamber; *E*, gas inlet; *k*, basin, or tank containing wash tar; *r*, radiator, or steam coil; *l*, rotary tar pump; *m*, preheater for wash tar; *s*, insulated connection from tank (*k*) to pump (*l*).

In order to keep the wash tar at the desired temperature, the steam pipe from *m* is beneath pipe *s*.

The hot wash tar is pumped from tank *k* through the insulated connection *s* and preheater *m* to the Pelouze condenser *A* through the overflow pot *n;* any surplus tar overflows at *O* and *p* and returns to tank *k*.

The tar overflows from the Pelouze through *b* and *d*, *e* and *g*, into the upper chamber *C* of the washer, where it is picked up by the washing cones within the chamber and spread out over the entire gas space, the depth of the spray being from 8 in. to 14 in. depending upon the size of the washer. The gas is thus brought into intimate contact with the hot wash tar, and is subjected to a thorough washing, the wash tar as well as the tar expelled from the gas, overflowing through the gas port to the next lower washing chamber; here the wash tar is again placed in circulation by the cones in this chamber, and the total combined tar finally leaves the washer through the pot *i* attached to the gas inlet connection, and by means of overflow *h* enters tank *k*, all surplus tar from this tank flowing off to the tar storage.

In order that the maximum results may be secured, the wash tar should be constantly circulated through the washer, but it is not always necessary to circulate it through the Pelouze condenser, this omission being dependent upon the condition of the tar in the gas. The amount of hot tar to be circulated through the washer may vary from 0.5 to 2.5 gallons per 1000 cubic meters of gas per hour; larger volumes of gas require proportionally less circulating tar than do smaller volumes, but the amount of washing tar circulated must be so regulated as to prevent the temperature of the gas reducing the temperature of the wash tar.

The circulating wash tar should be pumped through the preheater *m* before it enters the washer, this preheater being supplied with a steam coil, and in some cases it may be necessary to insulate the tank containing the wash tar, depending upon its location, and even the washer proper with some insulating material, in order to increase the efficiency, as many of these washers are set up in the open in Europe, being thus exposed to the weather.

The tank containing the wash tar is also provided with a steam coil, or radiator, made in one piece in order to prevent leaks and thus mix water with the tar. Care must be exercised in operation to the extent of preventing the deposit of thick tar in the Pelouze condenser, and if the washer should be stopped for any reason, it must be emptied of tar at once in order to avoid cooling the tar and thus clogging up the passages.

Table I gives the results secured in washing with hot tar, the washer being supplied with a Pelouze condenser in the one instance, but not in the other.

TABLE I—FELD HOT TAR WASHING

Washer Without Pelouze Condenser

| Gas temperature at Inlet to Washer | Tar Content in Grains per Cu. Ft. | | Grains Removed | Efficiency, per Cent | Gas passed per 24 Hrs., Cubic Feet |
|---|---|---|---|---|---|
| | Inlet | Outlet | | | |
| 131° F. | 11.512 | 0.2930 | 11.219 | 97.46 | 2,463,000 |
| 127° F. | 10.386 | 0.2160 | 10.170 | 97.92 | 2,453,832 |
| 129° F. | 10,818 | 0.2930 | 10.525 | 97.29 | 2,341,800 |
| 129° F. | 13.518 | 0.4170 | 13.101 | 96.92 | 2,397,000 |
| 126° F. | 9.907 | 0.5250 | 9.382 | 94.70 | 2,400,000 |
| Washer With Pelouze Condenser | | | | | |
| 140° F. | 10.050 | 0.0436 | 10.0064 | 99.56 | 2,600,000 |
| 194° F. | 13.100 | 0.0872 | 13.0128 | 99.34 | 2,600,000 |

The Feld process of tar washing was installed in a works in Bohemia in 1907, and the tar was fractionated into pitch, heavy oil, and light oil, with the result that the tar produced by the old method of condensation sold for $5 per ton, while with the use of the Feld system producing the oils direct from the gas, the equivalent of this ton of tar sold for $16.

### Naphthalene

Naphthalene ($C_{10}H_8$) is a hydrocarbon and has a melting point of 174 deg. Fahr., a boiling point of 424 deg. Fahr., and it sublimes at lower temperatures. The deposition of naphthalene in a solid state in the mains or apparatus causes many operating difficulties, as it decreases the cross-sectional area of the gas conduits and thus produces quite some back pressure on the works.

The presence of naphthalene in the gas is probably due to the high heats employed in present-day carbonization, and it is presumed that these high heats cause a partial distillation of the tar with the consequent formation of naphthalene.

The greater portion of the naphthalene produced especially with high distillation or carbonization temperatures, goes over into the tar, the gas containing only a portion of the naphthalene vapor, its maximum content being dependent upon saturation at various temperatures, but outside of the temperature of carbonization the amount of naphthalene present in the gas is also due to the character of the coal used, and upon the time of contact between the gas and hot coke and hot retort walls.

The amount of naphthalene required to saturate a gas varies according to different investigators, none of them agreeing with each other.

In order to avoid stoppages in the pipe connections due to sublimation, it would be necessary to cool the gas as nearly as possible to a temperature corresponding to that of the gas in the buried mains, but as it is almost impossible to do this during cold weather, it becomes necessary to remove the naphthalene from the gas by means of a suitable extracting medium.

The best solvents for this purpose are anthracene oil, creosote oil, and water gas tar; the tar from vertical retorts has also been used for this purpose, but this tar must first be subjected to complete cooling.

If all of the naphthalene should be removed from the gas, the latter would suffer considerably in candlepower, and no more should be expelled than what would produce sublimation with consequent stoppages.

Under ordinary conditions, 100 grains of anthracite oil will absorb from 10 to 25 grains of naphthalene, according to temperature, but before using this oil from 3 to 4 per cent of benzol should be added, this addition leading to greater extraction efficiency, this efficiency being further increased by thoroughly and slowly cooling the gas, as the absorption is most complete at a temperature of from 60 deg. to 70 deg. Fahr.

One per cent of creosote oil will, under ordinary conditions, absorb one per cent of naphthalene, by weight, but this absorption is dependent upon the amount of phenols present.

Water gas tar will absorb from 18 to 20 per cent. of its own weight in naphthalene, this absorption efficiency also being dependent upon the amount of phenols present.

If water gas tar, or if water gas oil, is used as the absorbing medium, it can be run back to storage bearing its naphthalene burden, as the latter is not detrimental to the further use of the tar or oil, but if antracene or creosote oil is used this oil can be regenerated for further use by being distilled and condensed, the naphthalene crystals being thus caused to crystallize out.

An attempt has lately been made to use naphthalene as fuel in internal combustion engines, and some success has been met with in this direction; the present drawback seems to be the fact that it is necessary to start the engine with gas or some liquid fuel, and to so operate it until the heat generated by the engine is sufficient to melt the naphthalene, after which the latter is fed to the engine, vaporized, and exploded. Complete success in this direction would soon open up another source of revenue to the producer of coal gas.

It may be interesting to state that a locomotive operating on naphthalene has recently been constructed in France; this locomotive is provided with four cylinders, each two cast en-bloc, 5-5-in. bore by 8-in. stroke, 70 hp being developed at 950 r.p.m. This machine is provided with two carburetors, one used on starting with spirit, and the other for the naphthalene. The carburetor used in connection with the naphthalene is cast en-bloc with the reservoir in which the naphthalene is melted, double walls for the circulation of cooling water being provided, the temperature of this water being maintained at 212 deg. Fahr., thus maintaining a constant melting temperature.

### Cyanogen

Cyanogen ($C_2N_2$) is a gas composed of carbon and nitrogen, and it is probably produced during the period of carbonization in the form of hydrocyanic acid by the decomposition of some of the ammonia due to contact with the hot coke in the retort, as per the equation,

$$C + NH_3 = HCN + H_2,$$

and the amount of cyanogen produced by the carbonization of any particular coal bears a certain relation to the amount of nitrogen contained in the coal.

The removal of cyanogen from coal gas is of decided advantage for two reasons, (1) owing to its corrosive effect on works apparatus; (2) because it is a valuable by-product under certain conditions; also if cyanogen is permitted to pass on into the purifiers, it will be found to enter into combination with the iron in the purifying material, thus rendering a certain portion of this iron inactive for hydrogen sulphide extraction; on the other hand, the sale of spent oxide containing a high percentage of cyanogen is more remunerative than if it contained only sulphur, as this oxide is often purchased on the basis of its "prussian blue" contents only, "prussian blue" being the name applied to this cyanogen combination.

The revenue to be derived from the extraction of cyanogen from coal gas is dependent upon the amount of coal carbonized and upon the market price of the product, the latter fluctuating constantly; it is certainly not a remunerative proposition for works carbonizing less than 250 tons of coal per day, as the same labor expended on a plant of this size, can readily handle the proposition in one of double the capacity.

The estimated revenue in a plant carbonizing 250 tons of coal at the works, and 750 tons at another, the sludge from both being worked up in one plant, after deducting operating expenses and 6 per cent interest and 6 per cent for depreciation, amounts to $27,935 per year, and this, without the additional revenue, to be derived by the production of ammonium sulphate from the cyanogen press liquor, this liquor being sold on the basis of concentrated ammonia. Besides this revenue, the extraction of cyanogen in this case shows an aid of 22 per cent in the action of the purifiers, or the life of the oxide is increased by 22 per cent.

The two systems of cyanogen recovery which have met with the most pronounced success, is that of Bueb, and the one devised by Feld, the former making an insoluble ferro-cyanide coke, and the latter a soluble cyanide sludge.

For a description covering the extraction of cyanogen by the Bueb process, attention is called to the paper read by Mr. M. E. Mueller during the 1910 meeting of the Institute, and which appeared in the Proceedings of that year.

The Feld process of cyanogen extraction differs from that of Bueb in that it is applied after the ammonia has been removed from the gas, this alkali being replaced with milk of lime in the copperas washing medium. The combined solution of lime and copperas is run into the Feld vertical washer, the resultant sludge coming from the bottom of the washer being boiled and then filter-pressed, the product coming from the filter press being calcium ferro-cyanide.

The product coming from either the Bueb or Feld plant, is usually worked up into potassium ferrocyanide, and in this case the working up of the sludge produced by the Bueb system requires additional apparatus for the removal and concentration of the ammonia carried in the sludge, while the working up of Feld sludge obviates the necessity of this ammonia apparatus, as the Feld system embraces the removal of cyanogen from the gas after the ammonia has been extracted.

### Ammonia

Ammonia is a product derived from the destructive distillation of coal, and it results from the union of nitrogen with hydrogen, or $N + H_3 = NH_3$; besides being an important source of revenue, the removal of ammonia from gas is necessary on account of its destructive influence on the brass and copper work of meters and gas fittings; when burned with gas it gives off noxious fumes of oxides of nitrogen.

The usual method employed for the removal of ammonia depends upon its solubility in water, and at ordinary temperatures water can absorb about 708 times its volume of pure ammonia gas, the absorption increasing with a decrease in water temperature, or

| | | | | |
|---|---|---|---|---|
| One volume of water at | 32° F. | will absorb | 1050 | volumes of $NH_3$ |
| " | 50° F. | " | 813 | " " |
| " | 59° F. | " | 727 | " " |
| " | 68° F. | " | 654 | " " |
| " | 77° F. | " | 586 | " " |
| " | 183° F. | " | 180 | " " |

providing the pressure of the ammonia gas is equal to that of the atmosphere, and if the gas carries no tar burden.

The usual gas works method of operation. as practiced in America, removes the ammonia by condensation and washing, the first portion of the ammonia being removed in the hydraulic main due to the condensation of water vapors, which thus absorb ammonia. Cooling the gas in the condensers also causes the deposition of quite an amount of water which in turn absorbs more ammonia, the final ammonia being removed in the scrubbers or mechanical washers, using as little wash water as is consistent with the result desired, viz.: strong liquor.

Raw ammonia liquor from the plant usually contains from 1 to 2 per cent of ammonia, and due to the cost of transportation, it would not, in most cases, be economical to sell this liquor in its diluted state; the raw liquor is, therefore, usually worked up for one of the following ammonia products: (1) Concentrated liquor; (2) aqua ammonia; (3) sulphate of ammonia; but the product to be recommended for any particular gas works must necessarily depend upon local market conditions.

Concentrated ammonia is a product in which the raw liquor has been freed of a large portion of water, and it is used for producing other ammonia products.

Aqua ammonia is a solution of ammonia in distilled water, a great deal of it, in a dilute solution, being used for cleansing purposes.

Ammonium sulphate is produced by distilling the liquor, and absorbing in sulphuric acid; by passing the gas through an acid bath, thus absorbing the ammonia, or by combining the ammonia in the gas directly with the sulphur radical, discarding sulphuric acid.

The working up of the liquor is usually effected in continuous stills, Fig. 3, operating with a supply of live steam, and as the principle of design and operation is practically the same in the usual stills on the market, only one method will be described the other differing only in detail and not in principle.

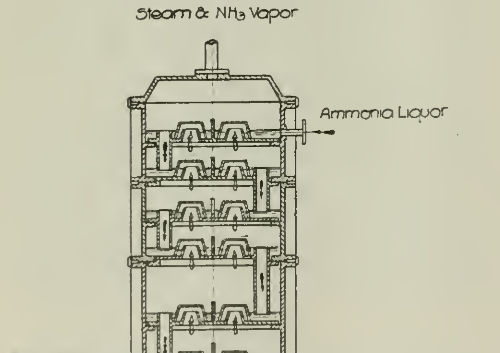


FIG. 3—AMMONIA STILL

The still usually consists of a series of superimposed sections, one mounted upon the other, constructed of cast iron, each section being provided with a steam passage in the bottom, covered with a hood or bell, and an internal overflow for liquor. These sections should be liberally provided with cleaning holes, by means of which access can be had to every part of the interior, so that the apparatus can be thoroughly cleaned without dismantling it. The liquor having been previously heated, enters at the top of the still and flows from section to section in a direction opposite to that of the steam, which enters at the bottom, passes up through the steam passages, and is caused to pass through the liquor by means of the hoods or bells.

The crude liquor is thus gradually brought to the boiling point, the free ammonia and other gases mixing with the steam in the upper portion of the apparatus. The milk of lime is introduced in small quantities into the lower or liming sections, the hoods of these sections having a somewhat deeper seal than the others, in order to permit of more efficient mixing of lime and liquor. A final boiling of the liquor in the lower sections completely liberates all of the fixed ammonia, and the stills should be so operated that the waste liquors leaving the bottom should not contain more than 0.005 per cent of ammonia.

If concentrated liquor is to be produced, the vapors coming from the still are washed in a lime washer in order to remove any carbonate of ammonia that may be formed, after which the vapors are condensed and run into storage.

The earning capacity of a concentrating plant operating in conjunction with a plant carbonizing 300 tons of coal per day, should be, with ammonia at eight cents per pound, about $25,788 per year, or

| | | |
|---|---|---|
| 375,000 lbs. of ammonia at 8 cents | | $30,000 |
| Labor | $1,830 | |
| Materials | 1,922 | |
| Miscellaneous | 460 | |
| Total operating cost, less interest and depreciation | | 4,212 |
| Profit per year | | $25,788 |

If the weak liquor, as produced in the works, can be sold as such, and if the ammonia in this liquor, based on the above prices of concentrate, is worth 6 cents a pound, the yearly gross revenue for this ammonia should be $22,500, but from this would have to be deducted the added freight due to shipping a larger bulk, if the ammonia liquor is to be transported away from the works, as well as pumping charges. In order to make the sale of weak liquor a profitable undertaking as compared with concentrate, it would be necessary that an ammonia works, which would take the entire output of liquor, be established in very close proximity to the gas works.

If aqua ammonia is to be produced, the vapors from the still are sent into lime washers, coolers, charcoal filters, oil washers, caustic soda washers, and finally into the absorbers.

The earning capacity of an aqua plant of the same size as that quoted above, should be about $47,030 per year, or

| | | |
|---|---|---|
| 780 tons of 26 Be' aqua at $102 | | $79,560 |
| Labor | $3,630 | |
| Materials | 7,610 | |
| Miscellaneous | 21,290 | |
| Total operating cost, less interest and depreciation | | 32,530 |
| Profit per year | | $47,030 |

If sulphate is to be made from the ammonia vapors, these vapors are sent into the saturators containing sulphuric acid, where the ammonia and the acid combine to form the sulphate, and the earning capacity of such a plant of the same size as those quoted above, should be about $30,809 per year, or

| | | |
|---|---|---|
| 727 tons of sulphate at $60 | | $43,620 |
| Labor | $1,830 | |
| Material | 10,221 | |
| Miscellaneous | 760 | |
| Total operating cost, less interest and depreciation | | 12,811 |
| Profit per year | | $30,809 |

The net earnings of these three plants is based on 250 maximum working days.

During the last fifteen years, the attention of investigators has been turned toward an endeavor to simplify the methods used to produce ammonium sulphate from the product due to coal distillation, and instead of treating the gas liquor itself, as in the old or indirect system just described, the endeavor has been to pass the gas directly into and through the saturator, which is a closed one in this case; this method of procedure has been termed the "direct process" and, as the name indicates, it is a reversal of the old method. Other investigators have proceeded along somewhat different lines, and while passing the gas through the closed saturator, they, at the same time, vaporize the ammonia produced by previous condensation and then pass these vapors into the saturator in conjunction with the gas, this latter development being known as the "semi-direct" process.

The Feld system is even more truly a "direct process" than any of the methods mentioned above, as saturators containing sulphuric acid are not used, and when it is remembered that the production of one ton of sulphate requires approximately one ton of acid, the importance of this advanced step can be realized, Feld combining the sulphur in the gas with the ammonia, thus producing ammonium sulphate by his polythionate process, no other oxydizing agent, except atmospheric oxygen being required, and the latter is used only in the sulphur stove where the sulphur is burned to form sulphur dioxide, this sulphur stove thus displacing the sulphuric acid factory which has hitherto been a necessity.

The method of operation can best be understood by following the diagram, Fig. 4. The plant is started by filling the two generator tanks *B* and *C* as well as the wash liquor tank *D* with weak ammonia liquor from the

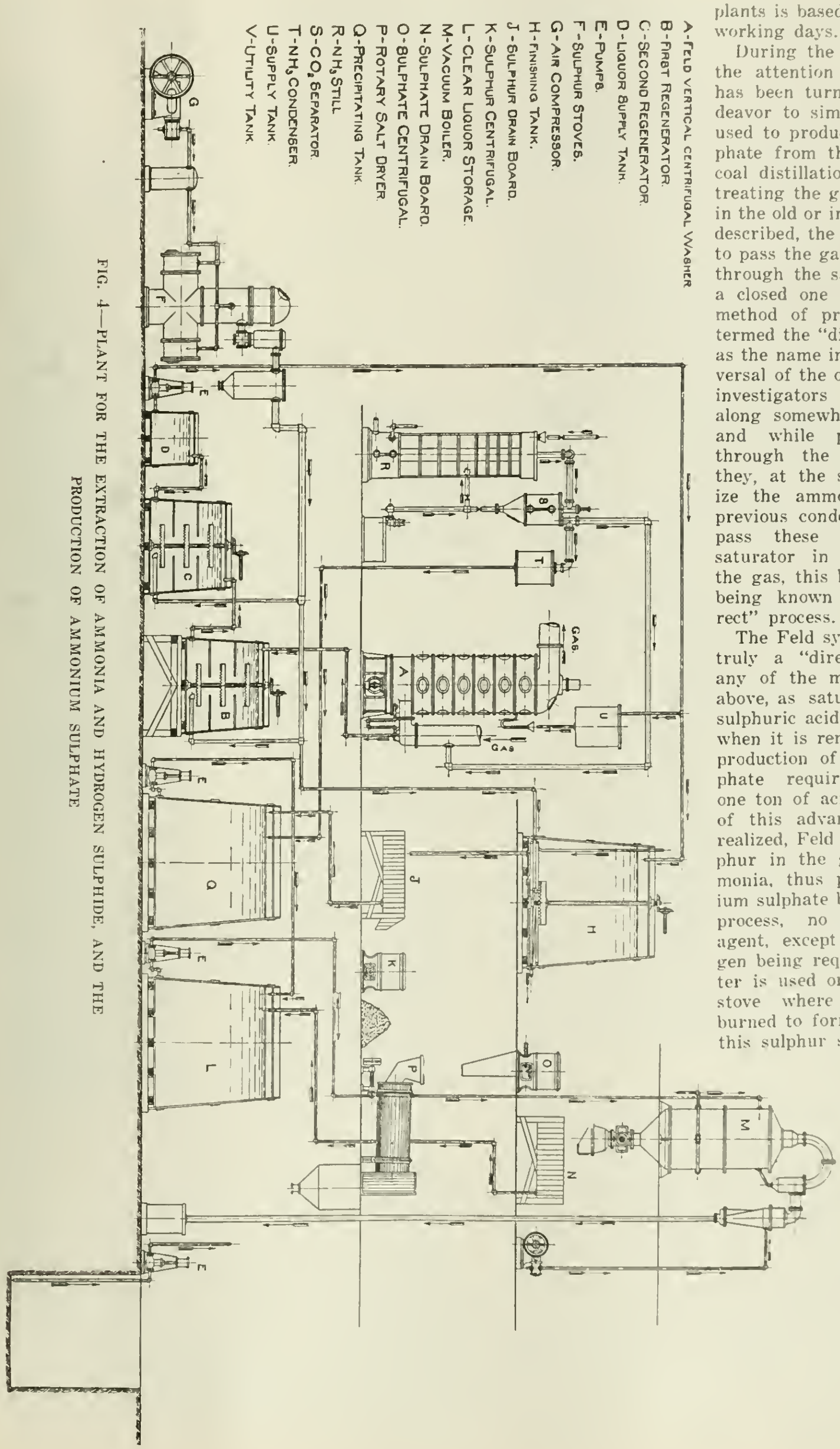


FIG. 4—PLANT FOR THE EXTRACTION OF AMMONIA AND HYDROGEN SULPHIDE, AND THE PRODUCTION OF AMMONIUM SULPHATE

works or with fresh water, this liquor or water being then pumped into the supply tank *U*, from whence it flows into the top of the washer *A*. Ammonia extraction immediately follows, and the liquor flows from the bottom of the washer as thio-sulphate, entering regenerator *B* where it is treated with sulphur dioxide coming from the sulphur stove *F*, the sulphur dioxide being forced through the liquor due to pressure produced by the compressor *G*. The overflow from regenerator *B* enters regenerator *C*, where a further treatment with sulphur dioxide is effected, and then enters the wash liquor tank *D*, from whence it is again pumped to the washer.

Alternately treating the liquor with sulphur dioxide and with crude gas forms polythionate in the first instance and thio-sulphate in the second, the polythionate being the active washing medium; an equivalent amount of hydrogen sulphide is removed from the gas in conjunction with the ammonia in the washer.

When the liquor has obtained a strength equivalent to 35 or 40 per cent ammonium sulphate, a portion of this concentrated solution is pumped into the oxidation or finishing tank *H*, it being replaced in the circulating system with weak liquor from prior condensation. In the finishing tank *H* the polythionate liquor is treated with heat through the medium of a steam coil, and some sulphur dioxide, if this should be necessary; by this treatment the thio-sulphates are transformed into polythionates which are in turn decomposed into sulphate and free sulphur.

The liquor, when decomposed, is drawn off from the finishing tank onto the sulphur drain board *J*, and the free sulphur, which is in the form of hard grains, is placed in the centrifugal *K* where its moisture is expelled; this sulphur is returned to the sulphur stove *F* for the forther production of sulphur dioxide.

The liquor from the drain board *J*, as well as that from the centrifugal *K*, flows to the precipitating tank *Q*, where it is treated with some concentrated ammonia, or $(NH_4)_2S$ from the condenser *T;* this liquor is then transferred to the storage tank *L* and is pumped from there to the vacuum boiler *M*. The concentrated ammonia, or $(NH_4)_2S$, from the still and condenser is sent into the precipitating tank in order that any iron held in suspension may be thrown down, thus ensuring a clean, white salt; the amount of ammonia used for this purpose is very small, but it is all recovered in the sulphate. The liquor is evaporated in a vacuum (an open evaporator may be used if desired) in the boiler, and the salts are drawn out onto the drain board *N* and from there to the centrifugal *O* and rotary dryer *P*, the salts thus produced being ready for bagging and shipping. All mother liquor from the drainboard and centrifugal returns to tank *L* and is from thence pumped back into the boiler.

The still *R* is used for the purpose of evaporating any ammonia liquor thrown down by previous condensation, these vapors being returned to the gas at the inlet to the washer, a small portion of the vapor being sent into the condenser *T* for producing the $(NH_4)_2S$ used in the precipitating tank. The use of a still is dependent upon the method of operation; if Feld's system of hot tar extraction is installed a still will not be necessary, as there will be no precipitation of ammonia under these conditions; a still is also not necessary if the production of ammonia liquor does not exceed the amount of liquor required in circulation.

This process requires but very little expert control, the usual mechanics, attending the machinery being capable of making the necessary liquor tests after some little instruction.

The Bueb process for the extraction of cyanogen produces ammonium sulphate in solution, and therefore, this process, in combination with the Feld explained above, forms a very remunerative proposition.

The income from such a combined plant in a works carbonizing 300 tons of coal per day is approximately as follows, based on 250 maximum days per year:

| | | | |
|---|---|---|---|
| Cyanogen | 128,500 lb. at 13.25c. | | $17,025.00 |
| Sulphate | 1,349,250 lb. at 3.00c. | | 40,477.50 |
| $NH_3$ in press cake | 29,750 lb. at 7.00c. | | 2,082.50 |
| Total gross earnings | | | $59,585.00 |
| The operating expenses are: | | | |
| Materials | | $3,695 | |
| Steam | | 1,663 | |
| Power | | 2,688 | |
| Miscellaneous | | 1,000 | |
| Labor | | 2,500 | |
| Total operating expense | | | 11,546.00 |
| Net earnings per year less interest and depreciation | | | $48,039.00 |

## Benzol

While the removal of benzol from gas is not of remunerative interest to the coal gas producer under the present antiquated standard of gas sale by candlepower, it is of special interest to the by-product coke oven operator, and as all of the preceding data applies to both of these producers, the method of removing and purifying benzol, is herewith included.

Benzol is recovered from coal gas after the tar and ammonia have been removed, and all modern systems are based on the original process as carried out by Brunck in Germany in 1887. The gas is washed in a series of washers with light oil, this oil absorbing the benzol, after which the raw product is subjected to a number of distillations, producing benzol, toluol, xylol and solvent naphtha.

The Koppers Company states that the income due to the extraction of benzol from the gas produced by the carbonization of 2000 net tons of dry coal per day, is as follows:

| YEARLY RECOVERY | |
|---|---|
| Benzel, 67 per cent | 978,000 gallons |
| Toluol, 16 per cent | 234,000 gallons |
| Xylol, 8 per cent | 117,000 gallons |
| Solvent naphtha, 9 per cent | 131,000 gallons |
| Total | 1,460,000 gallons |
| With a gross income of— | |
| 1,460,000 gallons at 15 cents | $219,000 |
| Crude naphthalene, 330 net tons at $5.00 | 1,650 |
| Regenerated acid of 40° Bé., 360 net tons at $6.00 | 2,160 |
| Total gross income | $222,810 |
| The operating expense per year being— | |
| Raw material, consisting of wash oil, sulphuric acid, caustic soda | $15,000 |
| Steam for distillation, air compressor, loading pumps, acid regeneration and cooling water | 15,000 |
| Electric power for water pumps, oil pumps, agitator, illumination | 6,200 |
| Wages for three distillers and two helpers | 5,000 |
| Overhead expenses, fire insurance, maintenance and depreciation, assuming the cost of the complete plant to be about $300,000 | 30,000 |
| Calorific loss of the gas | 13,000 |
| Total operating expense | $84,200 |

giving a net profit of $222,810 — $84,200 = $138,610, or 46 per cent on the investment capital, and making the cost of producing one gallon

$$\frac{\$84{,}200}{1{,}460{,}000} = 5.8 \text{ cents.}$$

This profit is, of course, dependent upon the selling price of benzol and the cost of raw material.

The Bartlett Hayward Company, Baltimore, Md.

**Recording Liquid Meter.**—The Duquesne Light Company, of Pittsburgh, Pa., will employ two 300,000-lb. per hour Lea V-notch recording liquid meters of the Yarnall-Waring Company, of Philadelphia, Pa., for the measurement of condensate in their Brunots Island power plant. The Duquesne Light Company having previously installed three meters of the same capacity, now uses therefore five Lea recording meters for measuring the flow of water at the rate of 1,500,000 lb. per hour.

# Niagara Falls Meeting of the American Electrochemical Society

The twenty-sixth general meeting of the American Electrochemical Society was held on October 1, 2 and 3 at Niagara Falls. It was very well attended and favored by ideal weather. The arrangements, made by the Niagara Falls members of the Society, under the leadership of President F. A. Lidbury, were excellent and the whole meeting was a most enjoyable affair in its social functions and thoroughly successful in its professional features; the most novel and brilliant of the latter being the symposium on experimental electric furnace work on Saturday.

The total registration was well above 200.

The following is a complete alphabetical list of those who registered at the meeting:

Paul O. Abbe, New York; W. L. Adams, Niagara Falls, N. Y.; Geo. P. Adamson, Easton, Pa.; E. H. Acton, Quebec, Canada; T. B. Allen, Niagara Falls, N. Y.; Mr. and Mrs. W. H. Arison, Niagara Falls, Ont.; T. F. Baily, Alliance, Ohio; A. N. Barron, Cleveland, Ohio; L. E. Barton, Niagara Falls, N. Y.; R. A. Bayard; E. H. Bedell, Chicago, Ill.; R. C. Benner, Freemont, Ohio; W. B. Bennett, Niagara Falls, N. Y.; Mr. and Mrs. W. F. Bleecker, Canonsburg, Pa.; Miss Elaine Bleecker, Canonsburg, Pa.; W. L. Bliss, Niagara Falls, N. Y.; E. Blough, Parnassus, Pa.; Dr. and Mrs. Wm. Brady, Chicago, Ill.; C. J. Brockbank, Niagara Falls, N. Y.; Geo. F. Brindley, New York; M. J. Brown, Niagara Falls, N. Y.; Mr. and Mrs. deCourcy Browne, New York City; A. R. Bullock; J. T. Burt-Gerrans, Toronto, Can.; Joe F. Callahan, Niagara Falls, N. Y.; C. F. Carrier, Jr., St. Louis, Mo.; A. W. Carroll, New York City; H. R. Carveth, Niagara Falls, N. Y.; H. C. Chapin, Cleveland, Ohio; L. W. Chubb, Pittsburgh, Pa.; W. R. Clymer, Cleveland, O.; H. B. Coho, New York; Edw. H. Cole, Niagara Falls, N. Y.; Miss Sarah Coleman, Jonesboro, Ind.; W. G. Collinson, Niagara Falls, N. Y.; V. G. Converse, Niagara Falls, N. Y.; F. T. Cope, Alliance, O.; W. M. Corse, Buffalo, N. Y.; Mr. and Mrs. Alfred H. Cowles, Sewaren, N. J.; Wm. A. Cowan, Brooklyn, N. Y.; G. E. Cox, Niagara Falls, N. Y.; John A. Crowley, Brooklyn, N. Y.; J. S. Crider, Cleveland, O.; R. A. Crider, Cleveland, O.; T. E. Crossman, New York City; N. Cunningham, Timmins, Ont.; Thos. L. Cunningham, Niagara Falls, N. Y.; H. M. Cushing; C. Dantsizen, Schenectady, N. Y.; E. R. Dewart, Niagara Falls, Ont.; Bradley Dewey, Pittsburgh, Pa.; Jos. Dixon, Sheffield, Eng.; H. M. Doerschuk, Niagara Falls, N. Y.; J. V. N. Dorr, New York; H. L. Doyle, Niagara Falls, Ont.; C. L. Dunham, Niagara Falls, N. Y.; R. W. Earle, New York City; I. R. Edmands, Niagara Falls, N. Y.; John C. Egnia, Niagara Falls, N. Y.; R. M. Emblidge, Buffalo, N. Y.; L. S. Finch, Niagara Falls, N. Y.; E. C. Fish, Niagara Falls, N. Y.; Mr. and Mrs. F. A. J. Fitzgerald, Niagara Falls, N. Y.; R. E. Fowler, Niagara Falls, N. Y.; F. C. Frary, Minneapolis, Minn.; Mrs. P. M. French, Rochester, N. Y.; W. M. Frickes, Niagara Falls, N. Y.; Mrs. W. M. Frickes, Niagara Falls, N. Y.; A. O. Fuller, Niagara Falls, N. Y.; G. Furness, Niagara Falls, N. Y.; Miss V. M. Gallinger, Niagara Falls, N. Y.; R. E. Gegenheimer, A. E. Gibbs, Plainpoint, Pa.; J. T. Gibbons, Bauxite, Arkansas; I. K. Giles, Niagara Falls, N. Y.; H. W. Gillett, Ithaca, N. Y.; Mr. and Mrs. B. L. Glascock, Niagara Falls, N. Y.; J. B. Glaze, Niagara Falls, N. Y.; C. M. Graves, Niagara Falls, N. Y.; J. R. Griffith, Niagara Falls, N. Y.; J. J. Geraty, Philadelphia, Pa.; Donald S. Hake, Niagara Falls, N. Y.; H. M. Hall, Maasena, N. Y.; C. G. Hardie, Buffalo, N. Y.; G. A. Hendrie, Niagara Falls, Ont.; Carl Hering, Philadelphia, Pa.; Alfred Herz, G. K. Herzog, Massena, N. Y.; F. N. Hicks, Niagara Falls, N. Y.; A. T. Hinckley, Niagara Falls, N. Y.; E. C. Hoffman, Niagara Falls, N. Y.; J. A. Holladay, Niagara Falls, N. Y.; L. S. Holstein, A. H. Hooker, Niagara Falls, N. Y.; H. W. Hooker, Niagara Falls, N. Y.; W. S. Horry, Niagara Falls, N. Y.; Mr. and Mrs. L. E. Howard, Lockport, N. Y.; W. F. Hubley, Newark, N. J.; O. Hutchins, Niagara Falls, N. Y.; D. A. Johnson, Chicago, Ill.; L. E. Imlay, Niagara Falls, N. Y.; J. A. Johnson, Niagara Falls, N. Y.; A. J. Jones, Niagara Falls, N. Y.; W. McA. Johnson, Hartford, Conn.; H. T. Kalmus, Kingston, Ont., Canada; Wm. Kastner, Buffalo, N. Y.; Mr. and Mrs. H. W. Kellogg, Niagara Falls, N. Y.; J. Kelleher, Toronto, Ont.; Mr. and Mrs. Frank R. Kemmer, Niagara Falls, N. Y.; F. L. Koethen, Niagara Falls, N. Y.; H. W. Lacey, N. Tonawanda, N. Y.; W. Laib; W. E. Lambert, Niagara Falls, N. Y.; P. E. Landolt, New York; A. M. Lawson, Niagara Falls, N. Y.; C. E. Leffel, Mr. and Mrs. F. A. Lidbury, Niagara Falls, N. Y.; M. G. Lloyd, Chicago, Ill.; Fred J. Longley, Niagara Falls, N. Y.; D. A. Lyon, Pittsburgh, Pa.; G. A. B. Lyster, Niagara Falls, N. Y., James H. Macbeth, Niagara Falls, N. Y.; J. H. MacMahon, Niagara Falls, N. Y.; J. R. MacMillan, Niagara Falls, N. Y.; Chas. G. Maier, Niagara Falls, N. Y.; W. Judson Marsh, Niagara Falls, N. Y.; J. G. Marshall, Niagara Falls, N. Y.; H. C. Martin, Niagara Falls, N. Y.; E. J. K. Mason, New York, N. Y.; F. C. Mathers, Bloomington, Ind.; M. E. McDonnell, Altoona, Pa.; Max Mauran, Niagara Falls, N. Y.; W. A. McKnight, Niagara Falls, N. Y.; J. D. McMahon, Niagara Falls, N. Y.; Mr. and Mrs. Ralph McNeill, New York; J. A. McSweeny, Niagara Falls, N. Y.; C. E. K. Mees, Rochester, N. Y.; W. G. Merriman, Lockport, N. Y.; D. R. Miller, Niagara Falls, N. Y.; John A. Miller, Buffalo, N. Y.; W. L. Miller, Toronto, Ont., Canada; J. B. Morden, Niagara Falls, N. Y.; Wm. C. Moore; Mr. and Mrs. W. R. Mott, Cleveland, O.; G. C. Moyer, Niagara Falls, N. Y.; J. M. Muir, New York; John H. Nee, Niagara Falls, N. Y.; J. G. Nelson, Niagara Falls, N. Y.; A. Neubeck, Buffalo, N. Y.; Fredk. G. Newell, Niagara Falls, N. Y.; J. D. Oille, Niagara Falls, N. Y.; J. L. Osborne, Niagara Falls, N. Y.; C. R. Pafenbach, Lockport, N. Y.; C. L. Parsons, Washington, D. C.; T. A. Patterson, Niagara Falls, N. Y.; L. A. Pettebone, Niagara Falls, N. Y.; N. Petinot, Niagara Falls, N. Y.; A. G. Porter, Niagara Falls, N. Y.; Mrs. A. G. Porter, Niagara Falls, N. Y.; A. F. Prenster, Niagara Falls, N. Y.; J. W. H. Randall, East Jordan, Mich.; Geo. R. Rayner, Niagara Falls, N. Y.; Jos. W. Richards, South Bethlehem, Pa., E. F. Roeber, New York; Miss Marie H. Rose, Niagara Falls, N. Y.; W. Ross, Niagara Falls, N. Y.; A. J. Rossi, New York; Prof. & Mrs. G. A. Roush, South Bethlehem, Pa.; J. M. Rowland, Niagara Falls, N. Y., D. A. Russell, Youngstown, Ohio; S. S. Sadtler, Philadelphia, Pa.; Mr. and Mrs. L. E. Saunders, Niagara Falls, N. Y.; E. S. Schartzer, Niagara, Falls, N. Y.; H. C. Schlatter, Niagara Falls, N. Y., C. G. Schluederberg, Pittsburgh, Pa.; S. R. Scholes, Pittsburgh, Pa.; C. M. E. Schroeder, Rutherford, N. J.; Mrs. S. R. Scholes, Pittsburgh, Pa.; Mr. and Mrs. E. M. Sergeant, Niagara Falls, N. Y.; A. F. Shaltuck, Detroit, Mich.; C. E. Skinner, Wilkinsburg, Pa.; Lewis B. Skinner, Denver, Colo.; Mrs. Lewis B. Skinner, Denver, Colo.; Mr. and Mrs. A. W. Smith, Cleveland, Ohio, W. A. Smith, Niagara Falls, N. Y.; Walter F. Smith, Philadelphia; W. O. Snelling, Pittsburgh, Pa.; Mr. and Mrs. R. C. Snowdon, Niagara Falls, N. Y.; E. C. Speiden, Niagara Falls, N. Y.; E. C. Sprague, Niagara Falls, N. Y.; S. G. Stafford, Coraopolis, Pa.; F. A. Stamps, Niagara Falls, N. Y.; Aug. F. Stilleson, Niagara Falls, N. Y.; G. D. Stilson, Niagara Falls, N. Y.; C. E. Taylor, Niagara Falls, N. Y.; A. Thompson, Buffalo, N. Y.; C. B. Thwing, Philadelphia, Pa.; Mr. and Mrs. M. Toch, New York City; Mr. and Mrs. F. J. Tone, Niagara Falls, N. Y., C. P. Townsend, Washington, D. C.; C. A. Tryoa, Niagara Falls, N. Y.; R. Turnbull, Welland, Ont., Canada; F. M. Turner, Jr., Pittsburgh, Pa.; F. O. Tyler, Niagara Falls, N. Y.; L. D. Vorce, Wyandotte, Mich.; Wm. H. Walker, Boston, Mass.; Mr. and Mrs. Walter Wallace, Niagara Falls, N. Y.; Fred B. Wheeler, Chicago, Ill.; Mr. and Mrs. R. H. White, Niagara Falls, N. Y.; E. H. Whitlock, Cleveland, Ohio; W. R. Whitney, Schenectady, N. Y.; A. M. Williamson, Niagara Falls, N. Y.; R. S. Wilo, Pittsburgh, Pa.; Mr. and Mrs. J. R. Wilson, Niagara Falls, N. Y.; N. A. Wilson, Niagara Falls, N. Y.; C. A. Winder; Mr. and Mrs. Chas. Wirt, Germantown, Pa.; J. A. Yunck, South Orange, N. J.

The first two meetings for the presentation and discussion of papers were held on Thursday morning and Friday afternoon at the Clifton Hotel, the third professional session, devoted to the symposium, at the FitzGerald Laboratories. Abstracts of all the papers and discussions are given below.

### Social Functions

On Friday evening a banquet was held at the Clifton Hotel. As a novel feature there were no after-dinner speeches, but instead a very elaborate illustrated lecture by Dr. C. E. Kenneth Mees, director of the research laboratory of the Eastman Kodak Company, on "the physical nature of color." The experimental demonstrations were charming.

Very enjoyable, too, was the excursion to Foster's Flats, on the afternoon of Thursday. This is a delightful spot near the Whirlpool Rapids, and the party enjoyed the presence of a local authority on the flora, fauna and history of the locality. The announcement in the program to the effect that "undoubtedly arrowheads can be found in large quantities in the vicinity" was made good, some one hundred or two having been specially cast for the occasion. The trick was discovered when some arrow-heads of Acheson graphite were found.

### Excursion

The morning of Friday was devoted to an excursion to manufacturing plants.

The Acheson Graphite Company's works were first visited, where the making and pressing of large amorphous carbon electrodes and their subsequent transformation into graphite in electric furnaces were found exceedingly interesting.

The plant of the Niagara Alkali Company, much enlarged in recent years, was next visited. It is interesting in more than one respect. It is the only American plant in which potassium chloride is electrolyzed, the Billiter-Siemens & Halske horizontal-diaphragm cell being used. The output of caustic potash is chiefly sold for special soaps, but also for electroplaters' supplies, etc. The chlorine is partly worked up into bleaching powder, partly liquefied and sold as liquid chlorine, and partly worked up into hydrochloric acid (by com-

SEMI-ANNUAL CONVENTI
AMERICAN ELECTRO-CHEMICAL SOCIE
NIAGARA FALLS, CAN. OCT. 1914

PHOTOGRAPH TAKEN BEFORE THE CLIFTON HOTEL AT THE

bination with hydrogen which is evolved at the cathode).

After this the party divided. One half visited the triple-plating department of the Spirella Corset Company, the other half the power plant of the Cliff Electrical Distributing Company (the old Schoellkopf plant).

### The Smoker

The smoker, a very big feature of the entertainment program, was held on the evening of Thursday at the Clifton Hotel. There were large, round, red and white badges with the inscription "Safety Last—Niagara Falls, the Home of Section Q." Mr. L. E. Saunders, president of Section Q, was in charge of the smoker and was very effective.

There was a long, continuous performance without an idle moment. Mr. J. Macbeth discussed the personnel of the local electrochemical industry of Niagara Falls from the point of view of a street sweeper who hears many things that other people don't hear.

Mr. F. A. Lidbury lectured on what was an alleged continuation of Dr. Bancroft's work on electrolytic flames, showing the phosphoresence produced by the solution of effervescent cathartics, the deposition on cooled porcelain tubes of metals from the steam of boiling solutions of those metals and other instances of "those remarkable phenomena which had completely escaped Dr. Bancroft's notice." The lecturer explained that as Dr. Bancroft had cast aspersion in his lecture on his (the lecturer's) knowledge of his own business, a "tu quoque" became necessary.

MAZDA LISA
A CARTOON FROM THE SMOKER

Mr. Max Mauran whistled and there was a sketch giving a life-like presentation of the proceedings of a factory inspection, conducted by a State factory investigation committee, entitled: "Show the ladies what you got."

The parts of the ladies were charmingly assumed by Messrs. D. Stubblefield and J. Glaze, while Mr. M. Bartlett presented with authority and Mr. P. McN. Bennie with forcefulness and Scotch accent the parts of Haskell-Jones and Angus-McBullgang, respectively manager and foreman of the Potash Carbide Abrasion Company of America. Messrs. R. Wilson, A. H. Hooker and A. T. Hinckley carried very naturally the parts of the workmen.

Slides, passed by the Censor—more or less personal, but all of them very amusing—illustrated the reports made by the different committees of Section Q. As an example we reproduce the Mazda Lisa cartoon from part II of the committee on advertising.

Then there were five entirely new songs, as well as all the old favorites of Section Q. They were not passed by the Censor. Hence we are only able to print one and a portion of another.

This is the song about Johnny, the plater:

"Johnny took some acetate, Johnny took some lead, Johnny took some poplar bark and stood it on its head, John added HCl until the bath was clear, But Johnny never knew why it plated out so queer.

"Johnny took some copper salt, dissolved in cyanide, And added dextrine, glue and snuff and aloes on the side, He spat in some tobacco juice and then he added beer, But Johnny never knew why it plated out so queer.

"Johnny used up fifteen volts for every gross of forks, Just as recommended in the platers' helpful talks, And other confidential hints were whispered in his ear, But Johnny never knew why it plated out so queer.

"O! Up came Banny with a supercilious air, And told him he'd been going wrong, and when and how and where, And Bennett wrote long papers then to make the matter clear, And now Johnny knows why it plated out so queer."

A portion of another song ran as follows:

"The furnace has a jolly time, Reducing tons of coke and lime, But when a carbon breaks, I guess, It makes an awful, awful mess.

"How useful is the humble cell, In breaking up NaCl, But when the diaphragm goes wrong, The Superintendent's face grows long.

"The Static is a patient beast, Abused the most and grumbles least, But when it does go on the bust, It gets most competently cussed.

"The load-peak meter is a pest, Its accuracy is a jest, It prints a great continuous lie, And when the bills come in they're high.

"The power house has an easy life, So free from troubles and from strife, It cooks up surges on its bus And sends them straight away to us.

"The abrasive's life is very hard, It grinds up metal by the yard, and carborundum is the one, The other's christened crystolon."

The smoker came to an untimely end at 11 o'clock through the heartless operation of the stringent Ontario liquor law.

NIAGARA FALLS MEETING OF THE AMERICAN ELECTROCHEMICAL SOCIETY

### Base-Metal Thermocouples

President Lidbury called the first professional session to order on Thursday morning.

A paper by Professor O. L. KOWALKE, of the University of Wisconsin, discussed the constancy of base-metal thermocouples as related to the microstructure.

Five different samples of thermocouples wires were investigated and the results are given in detail in the paper. The original structure as well as the structures produced by a two-hour heat treatment at 400 deg., 600 deg., 800 deg. and 1000 deg., respectively, were studied. From the results it appears that those metals which form solid solutions with one another, give the best results, providing that the thermo-electric force is satisfactory and the melting point high.

The characteristics of solid solutions were found for the following alloys: nickel-iron, low in iron; nickel-chrome; chromium-iron-nickel; aluminium-nickel; nickel-copper; constanton; excello.

Silicon does not appear to be a desirable constituent in a nickel alloy for thermocouple material.

Any segregation of the metal has an undesirable effect on the constancy of the couple. Wires containing but one metal showed a satisfactory structure.

The paper elicited an extended discussion.

Mr. W. R. Mott referred to the fact that freshly made alloys frequently change their structure and crystallize out after having been taken from the furnace. Silicon is peculiar in another way in its thermo-electric characteristics, since deoxidized pure silicon behaves differently from silicon containing dissolved silica.

Mr. C. B. Thwing, in a written communication, said that in a former investigation of the relation between thermo-electromotive force and coefficient of expansion he met some striking exhibitions of the effect of aggregation of crystals as changed by heat upon both of these properties of certain alloys and metals, for instance, antimony. He suggested that Professor Kowalke apply the same tests to platinum thermocouples. Such couples when damaged by long use may often be restored by glowing them with a current not sufficient to melt the wire, but to reach, say, 1500 degrees. Microphotographs of the structure before and after the heating would be of great interest.

Prof. Jos. W. Richards said it was a fact that so-called standard couples which had been standardized and probably accurately standardized in the laboratory of the maker, when brought to the works and used there, sometimes show variations of from 10 to 100 degrees C. from the standardization. Mr. B. L. Glascock referred to a recent case in which four couples, supposed to have been standardized by the manufacturer, when checked against a platinum, platinum-rhodium couple, varied from 8 to 52 degrees at 1000 deg. temperature. Mr. W. McKnight added that the couple, of secret composition, is manufactured for use at 1200 deg.

### Electrometric Titration

A paper on this subject, by Mr. HENRY ZIEGEL, of Brookline, Mass., concerns a possible technical application of the change in potential at the end point when a bichromate solution is reduced by a solution of ferrous salt.

The change in potential in a solution at the end point of a titration has been studied by several workers during the last fifteen years. Recently Hildebrand and especially Forbes and Bartlett, have studied this change in potential in the ferrous iron-bichromate titration. Under the conditions observed by the latter authors, this potential change is about 0.2 volt and even greater. The present author has been successful in applying this change in potential to the regulation of the burette stopcock in such a manner that the stopcock closes automatically when the end point of the titration is reached.

The apparatus used is similar to that of Forbes and Bartlett, with the following changes: In place of the usual galvanometer, a Weston No. 30 relay was used. Thus when the change in potential took place, immediate contact was made in a circuit having in it a telegraph sounder with a narrowed arm seven inches in length from fulcrum to tip. This sounder arm tip was connected to one side of the burette stopcock by means of a piece of fine chain. Final connection was made to the stopcock tip by a small brass cap cemented on with sealing wax. Such a device closed the stopcock, and a similar sounder was adjusted to the other extremity of the stopcock so that the latter would be opened by it.

Thus, at the initial potential in the solution to be titrated, the arm of the Weston instrument completed a circuit which opened the burette stopcock, and at the end point the change in potential caused the needle to swing a few hundredths of an inch, open the above circuit, and close the circuit containing the sounder which caused the stopcock to close. That is, the change in potential at the end point can be caused to close the burette stopcock mechanically, thus showing the first step in the accomplishment of titrations by other than manual operations.

The rapid stirring necessary was accomplished by using the elongated shaft of a cheap battery motor. This shaft was heavily platinum plated, and tipped with a deeply nicked disc of sheet platinum. This platinum formed the oxygen electrode. An ordinary form of calomel electrode was used. The galvanometer used was a rewound stock Weston No. 30 relay.

The procedure was to set the beaker containing the bichromate in place, close the stirring motor circuit, and then close the switch controlling the two sounders. The burette would then deliver until the end point was reached, when, due to the potential change, the stopcock would be closed by the second sounder. These two sounders were actuated by the delicate Weston instrument.

The author proposes to apply this apparatus to the automatic titration of iron after the direct procedure of Hildebrand and to the titration of zinc by ferrocyanide.

In the extended discussions which followed, Prof. G. A. Roush, referred to similar published work of two other authors though the titration had not been rendered automatic by them. He thought that by the use of such automatic methods, the time for routine analytical work, for instances, in iron and steel laboratories, could be largely reduced.

Mr. Warren F. Bleecker, on the other hand, thought such methods were academic and referred to a similar method he had employed in permanganate titration using a ray of light and its effect on a selenium cell.

President Lidbury thought there were cases where electrometric titration would have considerable advantages over ordinary methods. For instance, in determining very small amounts of chlorides in water, a silver electrode as an indicator gives an accurate sharp end point. The method is very sensitive. Another application is the determination of the acidity or alkalinity of solutions containing hypochlorites.

Dr. W. R. Whitney said that if we add the measurement of electrical resistance to this scheme of measuring electrometric forces, we have quite a group of possible electrical titrations. The resistance method is, for instance, useful for determining the neutral point in acid and alkali titration.

Dr. W. Lash Miller pointed out the accuracy of the author's method. In fourteen analyses made by the author's machine the number of cubic centimeters added automatically varied between 19.50 and 19.79, while in six spot plate checks, done manually, the variation was between 19.50 and 20.39.

Prof. Francis C. Frary thought that according to the author's figures the automatic results were 0.8 c.c. less than the manual results. Prof. Roush replied that the machine can be set to shut off the titration at any desired voltage so that one can adjust the operation to check exactly with his own titration.

Prof. Richards said that the time saved by the machine in titrations in large laboratories was not negligible.

President Lidbury suggested that the author's apparatus might be used as a simple control of certain large-scale industrial operations, for instance, in cases in which it is necessary to keep the solution neither acid nor alkali, but absolutely neutral.

Mr. Bleecker agreed that the method is accurate and that it is perfectly feasible to use it, but in practice there exists a prejudice against a complicated electrical device in a laboratory where one cannot afford expert attention.

Dr. William Brady thought that while electrometric titrations might be a good thing, they were not particularly applicable in iron and steel laboratories.

Mr. G. K. Herzog suggested the use of electrometric titration of chlorides in the determination of the flow of water by the titration method in hydraulic plants.

### Reproducibility of the Copper Electrode

In a paper by Professor Frederick H. Getman, of Bryn Mawr College, attention is called to the fact that in investigations of the e. m. f. of various concentration cells there is a frequent variation of the difference of potential between the common metals and solutions of their salts.

While the phenomenon appears to be quite general, in no case has it been more difficult to secure satisfactory reproducibility than with copper electrodes. A study of the reproducibility of the copper electrode was therefore undertaken. The chief results are as follows:

Of the various forms of copper electrode which have been studied, that in which spongy copper is employed is the only form which is constant and reproducible.

The irregularities observed with electrodes of massive copper and with electrodes of platinum covered with an adherent deposit of copper, may be ascribed to conditions of metastability. The spongy modification of the metal is to be regarded as the stable modification under ordinary laboratory conditions.

The spongy copper electrodes were fine platinum loops covered with a deposit of spongy copper obtained by electrolyzing a neutral solution of copper sulphate at high current density.

The paper was discussed by Messrs. W. C. Moore, G. A. Roush, W. R. Mott, J. W. Richards, Francis C. Frary, W. Lash Miller, and H. C. Chapin. The condition of the surface determines the e. m. f. and it is, of course, affected by mechanical or other treatment. Mechanical treatment causes strains in the metal and these have some connection with corrosion. The possibility of impurities (for instance, sulphides and hydrogen) in the copper deposit was also commented upon.

### Impurities in Cathode Copper

The sources of impurities in cathode copper were discussed in a paper by Mr. Lawrence Addicks, of Douglas, Arizona.

Several years ago, the author collected a large quantity of data in the endeavor to ascertain what rôle electrolyte included within the pores of the cathode body played in contamination, and many figures from the Raritan, A. S. & R., Balbach, Great Falls and Buffalo refineries were added to those available at the Chrome plant, with which he was especially concerned. The study proved to be too complex to yield conclusive results, but a number of relations were established.

Impurities in refined copper may (a) cause a low electrical conductivity; (b) result in brittleness or weakness; or (c) be a source of loss of by-products of value. The first class is represented by phosphorus, aluminium, silicon, arsenic and antimony; the second by bismuth, lead, tellurium, and selenium; and the last by silver, gold, platinum, and palladium. It is further interesting to note that class (a) forms with copper alloys of excellent mechanical properties, while class (b) is practically insoluble in copper, forming a brittle matrix around the copper grains in the cast bar.

From the refining point of view impurities may be due to (d) electrolytic deposition; (e) inclusion of electrolyte in the crystalline structure of the cathode; (f) mechanical contamination from anode slimes suspended in the electrolyte and attaching themselves to the cathode; and (g) substances entering during melting from furnace, fuel and tools, and from other outside sources. It must be remembered that the finished copper is guaranteed to run at least 99.88 per cent Cu, that it commonly does run 99.93 per cent in the melted bar and that it is very unusual to find 0.01 per cent of any one impurity except oxygen, probably as cuprous oxids in solid solution, or possibly some other dissolved gas, such as argon or carbon monoxide.

After a general discussion of the possible sources of each impurity, the author first takes up a detailed discussion of gold and silver.

Here abundant information is available, as the metal losses are always very closely watched. A very puzzling case developed, in that at two refineries the proportionate silver losses ran about twice the gold. A careful investigation brought out the fact that at one of them and probably at the other, the assay method used gave low results for gold on account of the very small quantity present and correcting this would doubtless bring the gold up to the silver figures. As the silver and gold in the anodes all go into the slimes, the cathode losses should be directly proportioned to the anode contents, assuming an equal amount of float slimes in the different refineries. With high current densities there is more disturbance in the tank, due partly to increased circulation than when low density is used. We should therefore expect increased percentage losses at plants where high current densities are obtained.

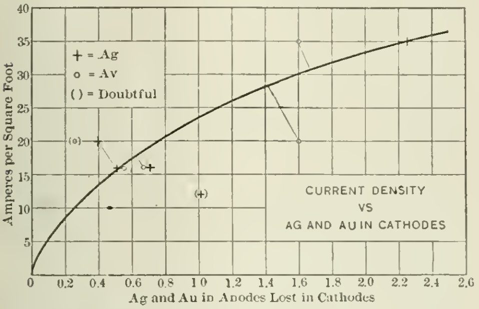


FIG. 1—CURRENT DENSITY VERSUS SILVER AND GOLD IN CATHODES

An inspection of Fig. 1 shows that current density has directly or indirectly a marked effect on the amount of slimes reaching the cathodes. Also that for densities between 15 and 20 amperes per sq. ft. (172-215 amp, per sq. m.), comprising most of the plants (the data in this paper are all from multiple-system plants; series plants are complicated by fouling of cathodes from adhering anode scrap) some 0.7 per cent of the silver and gold in the anodes adheres as slime to the cathodes, or in other words, the efficiency of refining is about 99.3 per cent. As the silver and gold in the anodes all goes into the slimes, this is the same thing as saying an equivalent amount of the anode slimes is carried over to the cathodes and knowing the analysis of the slimes, we should be able to figure the degree of fouling from this source. It will be of interest to test an actual case as in Table I.

TABLE I.

| Element | Per cent in Slimes | Per cent in Cathodes | Per cent Slimes X 0.000154 | Remainder | Per cent Fouling by Slimes |
|---|---|---|---|---|---|
| Ag | 33.82 | 0.00520 | 0.00520 | 0 | 100 |
| Te | 2.74 | 0.00023 | 0.00042 | Negative | 100 |
| As | 2.77 | 0.00105 | 0.00043 | 0.00062 | 41 |
| Sb | 5.40 | 0.00255 | 0.00083 | 0.00172 | 32 |
| Fe | 0.19 | 0.00330 | 0.00003 | 0.00327 | 1 |
| Ni | 4.98 | 0.00520 | 0.00077 | 0.00443 | 15 |
| Pb | 1.86 | 0.00070 | 0.00029 | 0.00041 | 41 |
| S | 2.01 | 0.00076 | 0.00031 | 0.00045 | 41 |

The case taken is one where the fouling as shown by the silver is twice normal, which, however, is of no harm as an example. Figures happen to be available for this period (which covers many million pounds of cathodes) for raw slimes, that is slimes that have simply been boiled free of soluble sulphates before sampling, whereas slimes are nearly always roasted and boiled in dilute sulphuric acid until practically copper-free before samples are taken and this operation somewhat disturbs the balance of impurities. The figures show clearly that except in the case of the insoluble group of elements before mentioned the slimes are not the only source of fouling. Except for iron and sulphur, the melting operation may slightly reduce impurities, but cannot increase them, so our argument is on the safe side.

The position can be attacked, however, on the ground that silver and gold are heavy and sink readily to the bottom of the tank, while the lighter oxidized impurities chiefly make up the float slimes. Emrich, in his paper on the "Refining of Blister Copper," presented before the American Institute of Mining Engineers, in 1904, argues backwards from the cathode analysis to prove this point and concludes that practically all the fouling comes from float slimes. Mr. Addicks thinks that some of the data submitted later show that his position is not sound. It is true that material collected at some distance away in launders, etc., runs disproportionately low in gold and silver, but this is truly floating material, whereas the cathode fouling takes place but an inch from the anode and the bottom of a cathode is known to be more foul than the top.

It may also be well to point out here that satisfactory samples cannot be obtained by drilling cathodes. In the first place, individual cathodes are irregular in purity, but more important is the fact that such samples always show too low results for impurity. This is due to the fact that adhering slimes are usually the nuclei of nodules forming rough deposits and it is necessary to take a relatively smooth part of the cathode in order to drill a hole. Nodules broken off and melted will often show ten times the impurities contained by a drilled sample of the body of the cathode. For these reasons it is necessary to fall back on melted samples or fire-refined cathodes in spite of the accompanying disadvantages, when undertaking work of this character.

The next element on which abundant data are available is arsenic, the ancient, but long since subdued, enemy of copper refining. It was early found that the presence of arsenic in an electrolyte was detrimental to the conductivity of the cathodes. A table is given in the paper for the average monthly value of arsenic in the electrolyte and the conductivity of the wire bars of one of the refineries for a year. The figures of this table are plotted in Fig. II, which clearly shows their correspondence.

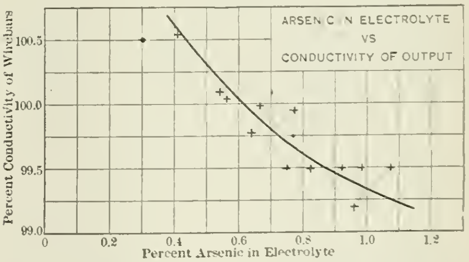


FIG. 2—ARSENIC IN ELECTROLYTE VERSUS CONDUCTIVITY OF OUTPUT

The same relation can be established by direct comparison of arsenic in electrolyte and in wire bars. In another table in the paper figures over a long range of time and for several plants, A. B. C. D., have been grouped, in some cases by periods and in some by classes. These figures plotted in Fig. 3 indicate an arsenic content in the wire bars of 0.0013 per cent when there is no arsenic in the electrolyte, which should be a measure of the fouling due to slimes. Anything above 0.0013 per cent would be due to either inclusion of electrolyte or electrolytic deposition of arsenic. Included electrolyte should vary directly with the composition of the solution, other things being equal. On the other hand, electro-deposited arsenic should increase with the voltage. Now plant C runs at very high current density and therefore at correspondingly high voltage, but no corresponding increase in arsenic in the wire bars can be noticed.

The figures, therefore, might seem to indicate inclusion as the chief source of fouling above the slimes minimum. These Great Falls figures (plant C), by the way, have since been summarized in a paper by Mr. W. T. Burns, Superintendent of that refinery, presented before the American Institute of Mining Engineers last year.

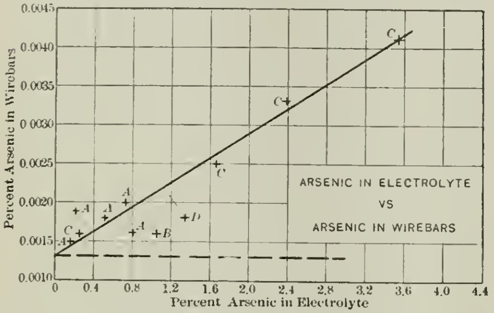


FIG. 3—ARSENIC IN ELECTROLYTE VERSUS ARSENIC IN WIREBARS

We may now turn to nickel for further light on this subject. Here we have an element whose sulphate has a very high decomposition voltage and it would seem unlikely that any nickel at all, regardless of the voltage, could be electro-deposited from a strongly acid solution. Table II gives results from nickel from various sources.

TABLE II.

| Plant | Representing | Per cent Ni in Electrolyte | Per cent Ni in Wirebars |
|---|---|---|---|
| A | 1909 | 1.95 | 0.0041 |
| A | 1910 | 1.60 | 0.0055 |
| A | 1911 | 1.73 | 0.0066 |
| A | 1912 | 1.32 | 0.0038 |
| A | 1913 | 1.78 | 0.0037 |
| B | 10 months | 0.973 | 0.0045 |
| C | Rough figures | 1.00 | 0.0016 |
| D | 1 lot | 0.594 | 0.0014 |

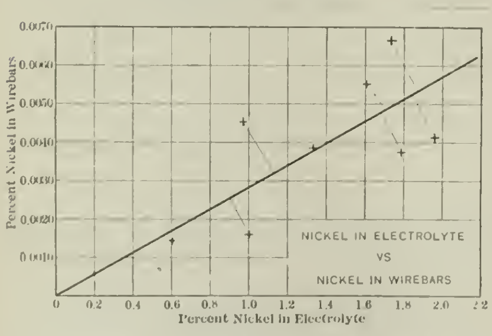


FIG. 4—NICKEL IN ELECTROLYTE VERSUS NICKEL IN WIREBARS

These figures when plotted in Fig. 4 indicate a straight line relation, as in the case of arsenic, but with no nickel in the cathodes when nickel is absent from the electrolyte. In other words, there is no fouling from the slimes. This may easily be so, as the slimes usually carry much less nickel than shown in Table I and even there the possible fouling is but 15 per cent. Further, this nickel is probably present as nickel oxide which is slowly soluble in electrolyte and float slimes may be largely cleansed of their nickel by the electrolyte. The surprising thing, however, is the large amount of nickel found in the cathodes. While a rise of 1 per cent in the content of the electrolyte shows in Fig. 3 a corresponding rise in the wire bars of but 0.0009 per cent, in the case of nickel it shows 0.0028 per cent, or three times as much. Emrich found the same thing. He says: "The large difference shown between the calculated and the observed values of nickel in the cathodes, is a mystery which I have been prevented from investigating."

Either a large quantity of arsenic is removed in the refining furnace, or we must accept electrodeposition of nickel, as the included electrolyte must be rigidly equivalent in the two cases. Those who have tried eliminating traces of arsenic in a refining furnace, except by the use of lime and soda ash or similar fluxes, which is done only in special cases where undesirable quantities of arsenic are present, will lean toward the nickel deposition explanation.

Some laboratory experiments indicated that while no nickel can be deposited from a pure acidulated solution of nickel sulphate, traces can be found in the cathodes when arsenic is added to the electrolyte, which suggests some ion based on the known affinity of nickel for arsenic. Also in an electrolytic separation of copper and nickel by the Hybinette process where the electrolyte was very high in nickel sulphate, copper containing as much as 0.1 per cent nickel has been produced. While these conditions are far from those obtaining in a copper refinery, the results greatly strengthen the deposition argument.

Finally we can examine the inclusion argument on the basis of the specific gravity of cathode copper. If from Fig. 3 a cathode runs 0.0022 per cent, minus 0.0013 per cent (due to slime) equals 0.0009 per cent arsenic due to inclusion of electrolyte running 1.0 per cent arsenic, the cathode would contain 0.0009 times 100 or 0.09 per cent of electrolyte of a specific gravity of let us say 1.15. As copper has a specific gravity in the neighborhood of 8.9, the amount present by volume would be 0.09 times 8.9 divided by 1.15, or 0.7 per cent, which is a measure of the porosity of the cathode. The specific gravity of the copper would be correspondingly diminished, but the amount would be so slight that the known facts do not contradict it. Cathode copper actually shows a specific gravity of about 8.9 similar to worked cast copper, but, on the other hand, we know that cathode copper is very hard—experimental work on direct production of electrolytic wire has given considerable trouble from wear on the dies—and we should therefore expect to find it denser than any other copper if it were absolutely non-porous.

We therefore arrive at about where we started, believing that slimes, included electrolyte and direct deposition all have a hand in the fouling of cathodes, but without being able to assign definite values to each. The relation between arsenic and nickel in electrolyte and in wire bars does seem to be reasonably established and this is of some practical value.

In a communicated discussion, Prof. Wilder D. Bancroft suggested that the fact that nickel is deposited with the copper to an extent increasing with the concentration is probably due to the fact that copper and nickel form a continuous series of solid solutions.

Dr. W. R. Whitney commented very favorably on Mr. Addicks' paper and emphasized the enormous extent to which the electrical industry is indebted to electrolytic copper refining, because of the high economy of a high-grade copper in certain types of apparatus.

### Electro-Analysis of Nickel

The electrolytic determination of nickel was the subject of a paper by Dr. W. JUDSON MARSH, of Cornell University. The paper points out a lack of accuracy in Classen's method and describes a new method which is quite exact.

The solution is made up as follows:

Nickel present (about 0.2000 g.) as $(NH_4)_2SO_4.NiSO_4.6H_2O$.

Ammonium hydroxide 15-20 cc. (Sp. g. 0.96).

Ammonium sulphate 5 grams.

Amperage 0.8 ± 0.1.

Potential difference 3.5 ± 0.2 volt.

Time required about 25 minutes. Room temperature.

Nitric acid, nitrates, and chlorides must not be present. Total volume of solution made up with $H_2O$ to 200 cc.

Electrolyze in a 350 cc. beaker using a 10-g. platinum wire gauze flag anode (52 mesh and 6 x 4.5 cm.) and a rotating (550-650 r.p.m.) pure Cu gauze (50 mesh and 5 cm. high x 3 cm. diameter) cathode. This electrode combination is much less expensive than the Classen dish and disk of platinum, requiring only one-fifth as much platinum as the latter. The Cu wire gauze cathode can be made easily, quickly, and cheaply. Stiff, twisted Cu wire is used for the stems and small Cu tacks are used to rivet the gauze together. One such cathode can be used for a great many determinations, as a fresh surface for deposition may be obtained by clipping a used cathode in 1:1 $HNO_3$ for a few moments. When well made and properly handled the cathodes which cost but a few cents and a few minutes work give results exactly as good as any platinum cathode. This makes it possible to run many more determinations than is usually possible with more expensive forms of apparatus. These cathodes have also been used successfully in the laboratory for the determination of copper, tin, cobalt, cadmium, bismuth, silver, and zinc. They have also been used in combination with the platinum wire gauze anodes for the determination of lead and manganese, both of which are deposited on the anode as peroxides.

In the discussion Prof. Francis C. Frary agreed that the new method, which is a modification of that of Fresenius and Bergmann, is easy and accurate. He stated that it is not necessary to rotate the cathode.

### Quantitative Determination of Radium

Prof. HERMAN SCHLUNDT, of the University of Missouri, contributed a paper on "some experiments on the quantitative discrimination of radium."

The accurate determination of radium in radium-bearing ores is generally conducted by the emanation method. With proper care the method is very certain and delicate. It is based upon the fact that the gaseous disintegration product of radium, the emanation, can be completely separated from radioactive materials, and that the equilibrium quantity is proportional to the content of radium. The minute quantities of radium emanation concerned in quantitative determinations of this kind are capable of exact measurement by electrical methods. The emanation is introduced into an air-tight electroscope or an ionization vessel connected with an electrometer, and the saturation current produced, under proper conditions, is proportional to the quantity of radium in the specimen from which the emanation was separated. The measuring instruments are standardized by means of known quantities of emanation from a standard radium solution, or from weighed amounts of uraninite or some other uranium-bearing mineral not of secondary origin, whose uranium content is known. In standardizing electroscopes by the latter method the radium content of the mineral is obtained by multiplying its uranium percentage by the proportionality factor $3.4 \times 10^{-7}$.

In the assay of radium ores the complete separation of the emanation from the specimen under examination is of course absolutely essential for accurate work. The collection and subsequent transfer of the gas is largely a matter of careful manipulation. The work of various investigators has shown that heating even to a white heat rarely expels all of the emanation from solids. The emanation, however, is completely liberated from the ore by dissolution and boiling. For substances soluble in water or acids several forms of apparatus for the quantitative separation of the emanation have been described.

Rocks and minerals that do not dissolve in acids upon heating, or are only partially soluble in them, require different treatment. One of the standard methods, known as the solution method, consists in fusion of a definite quantity of the material with four to five times its weight of mixed carbonates of sodium and potassium. The fused mass is lixiviated with water and washed with dilute sodium carbonate solution. The insoluble residue is dissolved in dilute hydrochloric acid. The alkaline and acid solutions are placed in separate flasks which are corked. On standing for a month the equilibrium quantity of emanation is again produced by the radium in solution. The emanation is then separated by boiling, and transferred to an emanation electroscope, and after three hours, when the activity is a maximum, the saturation current is measured.

Recently Joly and others have introduced fusion methods which appear to be more reliable than the solution method. The emanation is released from the rock by fusing it with a suitable flux—mixed carbonates of sodium and potassium are generally used—in a closed, electrically heated furnace at a temperature of over 1000 deg. C. The liberated emanation is collected, and after being freed from carbon dioxide, is transferred to a standardized electroscope for measurement.

The results obtained by the fusion method are generally higher than the values by the solution method. In the solution method it is difficult to avoid the formation of slight precipitates in the solutions, and these doubtless cause the separation of some radium, which does not release its emanation completely upon boiling.

The author has investigated several fusion methods and his chief results are as follows:

The solution method, that is, fusion with mixed carbonates, followed by solution and boiling, gave results that are only 70 to 80 per cent of the values obtained by the fusion method with mixed carbonates.

Fusion with mixed carbonates appears to be superior to fusion with potassium acid sulphate, although with the carnotite concentrate a slightly higher value was obtained with the sulphate.

Fusion with borax probably gives low values as a result of the retention of some of the emanation in the melt. At the temperatures attained in our experiments the evolution of gas and its flow through the melt is necessary for complete release of the emanation.

High emanating power in the cold indicates a large release of emanation by heating. In the case of the specimen of carnotite ore a rough assay may be made by merely heating the ore to bright redness.

A complete separation of the emanation from uraninite is obtained by solution in nitric acid and by fusion with some of the ordinary fluxes.

Dr. S. L. Lind (of the Bureau of Mines, Denver) stated in a communicated discussion that incidental to a determination of the radium to uranium ratio in carnotites he and Whittemore studied the quantitative de-emanation of carnotite in a large number of samples of ore by four different methods. As regard the method of fusion with $Na_2CO_3$ and $K_2CO_3$ mixture and subsequent dissolution and decomposition of the residues in dilute acid, they agree with Schlundt in obtaining results 10 to 20 per cent low. The method of dissolving directly in boiling 1-1 $HNO_3$ they found to give correct results, as indicated by the Ra to U ratio, and also by agreement with a direct ignition method, employing Jena glass and Meker burner, and they place the highest confidence in these two methods for this ore. With respect to the carbonate fusion method, they have failed in all carnotites to obtain anything approaching complete de-emanation which result they have been inclined to attribute to the influence of silicates on the viscosity of the melt, because they have successfully employed the same procedure for pitchblende and crude sulphates containing little or no silica. Dr. Lind emphasized that a method may be highly specific in its applicability to a given radioactive substance. For example, the ignition method is successful with carnotites, but a complete failure under the same conditions for crude sulphates, while the fusion method succeeded with pitchblende but failed with carnotite.

Mr. Warren F. Bleecker agreed that the measurement of radium is essentially an indirect method quite difficult to make and is little understood except by experts. What is needed is a method which is easily worked and reasonably accurate. The situation is rendered difficult by the fact that a method once successful is not applicable to all classes of ore without previous examination. The ratio between uranium and radium, only holds in whole rocks—not in works which have been in any wise treated, either mechanically or chemically. Mr. Bleecker exhibited samples of uranium carbide, made in the electric furnace. The substance is of great interest as it is probably the grandparent of radium. Uranium carbide has remarkable properties, not yet fully understood.

Mr. W. R. Mott asked Mr. Bleecker whether he had any trouble from poisoning since uranium was one of the most poisonous materials we can get within the body.

This remark started a lively controversy. Mr. Mott based his claim on the statements of French scientists. Mr. Bleecker combated most seriously any notion there might be as to the poisonous effect of uranium, on the basis of his experience of working with uranium ores and uranium salts on a large scale for several years. Of course, there is dust and that is bad, but there are no poisonous effects.

The result of the discussion was the appointment of a committee, consisting of Messrs. W. F. Bleecker, W. R. Mott, and A. R. Ledoux, to get at the facts as to the poisonous effects ascribed to uranium and vanadium.

### Silicidized Carbon-Silfrax

The first paper of the Friday afternoon session was presented by Mr. F. J. Tone, of the Carborundum Company, Niagara Falls, N. Y., on "Silicidized Carbon-Silfrax."

When solid carbon is acted upon by vapors of silica or silicon there is formed a silicon carbide product of the same shape as the original carbon but differing from carborundum in essential characteristics. To distinguish this form of silicidized carbon commercially, it has been given the name "silfrax." The properties and characteristics of the product vary with the temperature of formation. If the carbon article is heated in the amorphous zone of a carborundum furnace the temperature range of this zone being 1550 to 1820 deg., the product is amorphous in appearance, showing no crystals except under high magnification. It has a yellow color and a lusterless fracture. If the carbon is heated in the crystalline zone of the furnace, the temperature of this zone ranging from 1820 to 2220 deg., the material is of great density and plainly crystalline. Upon fracture it shows a steel black color and a metallic luster.

The depth of the silicidizing action is mainly a function of the time of reaction and the concentration of silicon vapor present in the furnace atmosphere. To obtain the best conversion a large excess of silicon vapor must be present and the mixture should contain silica largely in excess of the theoretical carborundum mixture. Under regular conditions with articles of pure carbon the maximum penetration is about ½ inch. Articles composed of a mixture of carborundum and carbon can be readily converted to a greater depth.

Chemical analysis of the two varieties made in the amorphous and crystalline zones show that both are silicon carbide and give no basis for regarding the products as new compounds of silicon and carbon. Microscopical examinations show in all cases the presence of the typical hexagonal crystals of silicon carbide.

Analyses of Silfrax

| | I | II | III | IV | V |
|---|---|---|---|---|---|
| SiC | 93.33 | 91.03 | 93.39 | 96.86 | 94.19 |
| $SiO_2$ | 1.14 | 4.63 | .75 | 0.94 | 3.10 |
| C free | 1.71 | 1.16 | 2.42 | 0.00 | 0.48 |
| Fe and Al | 3.84 | 3.94 | 2.07 | 1.42 | 1.62 |

I. Silfrax silicidized in amorphous zone of carborundum furnace.
II. Silfrax silicidized on edge of crystalline zone of carborundum furnace.
III. Do.
IV. Silundum.
V. Do.

Analyses of the SiC residue show it in all cases to consist of silicon and carbon in exact atomic proportions for SiC, and there can be no doubt that silicidized carbon by whatever name it may be called is silicon carbide.

Mr. Tone's paper then gives a number of interesting micrographs showing sections of carbon rods heated in both the amorphous and crystalline zones of the solicidizing furnace.

When carbon articles are subjected to the action of silicon vapors and molten silicon for a sufficient period the carbon is silicidized in the same manner as articles placed in a carborundum furnace, but the resultant product is carborundum containing varying proportions of pure silicon. Carborundum and silicon appear to be mutually soluble in all proportions and the physical and electrical properties of the carborundum are altered by the presence of silicon. A carbon block subject to this action in a silicon furnace furnishes a very suitable subject for investigation. Starting from the interior, which is unconverted carbon, the following zones are found:

(1) A greenish yellow product (*E*) not of great toughness and readily crushed down to the constituent grains, which are of great hardness. It is a poor conductor of electricity. On treatment with HF and $HNO_3$ a bright yellow residue is left, which is perfectly crystalline and contains no amorphous material. Even the smallest particles under high magnification are crystalline and practically colorless.

(2) A uniform dense gray product (*F*), having a non-crystalline appearance, very hard, tough and difficult to fracture. Treatment with HF and $HNO_3$ leaves a yellow crystalline material identical in appearance and properties with product *E*.

(3) A coarsely crystalline product (*G*), silver gray in color, very hard but more readily fractured than product *E*. The residue from treatment with HF and $HNO_3$ is mostly yellow, but contains some dark grains and is entirely crystalline.

CHEMICAL ANALYSIS OF PRODUCTS.

| | E | F | G |
|---|---|---|---|
| Free Si | 7.40 | 21.27 | 10.45 |
| SiC residue | 91.10 | 76.10 | 87.72 |
| Fe | .25 | 1.40 | .93 |
| Al | .45 | .57 | .36 |
| CaO | .80 | ..... | ..... |
| | 100.00 | 99.34 | 99.46 |
| *Residue from HF and $HNO_3$.* | | | |
| Si | 69.40 | .... | 69.32 |
| C | 29.33 | .... | 29.29 |
| Fe and Al | .... | .... | .10 |
| | 98.73 | ..... | 98.71 |

| | Apparent Density | S. G. of Residue | Resistivity Ohms cu. cm. |
|---|---|---|---|
| Product E | 2.91 | 3.16 | 174.0 |
| Product F | 2.88 | .... | 1.8 |
| Product G | 3.10 | 3.16 | 9.3 |

Mr. Tone showed micrographs made from products *E* and *F*.

In discussing the difference between silfrax and ordinary carborundum, it is necessary to consider the reactions of the carborundum furnace. The reaction of silica and carbon is one which under varying conditions may be made to give a variety of products. Silicon carbide, silicon, silicon monoxide, siloxicon, graphite and modifications or mixtures of these may all be produced by variations in the mixture proportions of silica and carbon, temperature, pressure, rate of energy expended and other factors. In the carborundum furnace, carborundum is initially formed by the reaction of silica vapors on carbon beginning at a temperature of 1550 deg. The first carborundum so formed is always associated with silica and may be regarded as a definite compound, as siloxicon, or as a mixture or solid solution of silica and silicon carbide. Whatever may be its composition when treated with HF and $HNO_3$ it is freed from silica and silicon, the residue being silicon carbide usually in the amorphous state.

At a higher range of temperature complete conversion occurs in accordance with the equation:

$$SiO_2 + 3C = SiC + 2CO \qquad (1)$$

On this equation is generally based the chemistry of the carborundum furnace, but as a matter of fact another reaction plays the most important part in the formation of carborundum and is here offered as a theory to explain fully all the phenomena of the furnace. Equation (1) explains only the conversion of carbon particles into carborundum *in situ*, the crystals or aggregates so formed being no larger than the original carbon particles. It is impossible to explain the growth of large crystals or crystals appreciably larger than the original carbon particles, unless it be granted that both the carbon and silicon when combining to produce these crystals are in the form of vapor. The largest and most perfect crystals are found in cavities or spaces where carbon and silicon in some form of gas or vapor have commingled and combined to form the solid crystals. Such form of carbon, however, cannot be vaporized carbon because it is well known that, at the temperature and vapor pressure of the carborundum furnace, carbon has no appreciable vapor tension. This is further proven by the fact that the effect of high temperature alone is to decompose carborundum, the silicon being vaporized and the carbon being left in a skeleton of the exact form of the original carborundum crystal.

If the vapor tension of carbon were appreciable these graphite pseudomorphs would not retain the perfect shapes of the corborundum crystals so generally observed. The theory is untenable, therefore, that carbon vapor and silicon vapor unite to form the large crystal growths.

To explain fully all the phenomena of the furnace the following reaction is necessary, the reaction being reversible: $2CO + 3Si = 2SiC + SiO_2$ (2)

Carbon monoxide and vapors of silicon and silica are known to be present throughout the furnace atmosphere, and equilibrium relationships and the direction of the reaction in equation (2) depend on the temperature, pressure and the concentration of the reacting substances. The direct reaction is the low temperature reaction and is exothermic. It occurs throughout the crystalline zone, and on it is based the building up of the large crystals from the small crystals formed by equation (1). The reverse reaction occurs in the hottest part of the furnace and next to the core, and explains the phenomenon of the local disappearance of carborundum. This is observed in the rounded formation of the crystals next to the core, which have lost their sharp outline on account of being washed by the silica vapors. It is further observed in the smooth channels and blow holes cut through masses of crystals by the blowing out of the furnace gases. That carborundum can be decomposed or oxidized by silica is well known and is one of the methods of producing silicon.

Reaction (2) further explains the phenomenon of the recrystallization of carborundum first discovered by FitzGerald. Recrystallization can only occur in an atmosphere of CO, $SiO_2$ and Si. It is impossible to recrystallize carborundum in a pure atmosphere of CO by the action of heat alone.

Applying these considerations to silfrax it will be seen that it differs fundamentally from ordinary carborundum in its mode of production. It is produced mainly in accordance with equation (1), that is from the action of silicon vapors on carbon *in situ*, and not from gaseous carbon compounds. The crystals composing silfrax, therefore, are very small and closely aggregated. The development of large carborundum crystals requires free space for the circulation of gases. The largest and most perfect crystals in the carborundum furnace are produced in cavities resulting from the settling of the charge and these cavities are located at a point on the temperature gradient representing approximately the equilibrium temperature for equation (2). In producing silfrax the density of the carbon article is such that when the initial coating is formed the pores are almost completely filled with SiC, making the further circulation of gases very slow and difficult. Reaction (2) which is vapor reaction cannot occur to any extent and the crystals remain small and closely compacted. Silfrax is a crystalline aggregate while ordinary carborundum is a crystal or crystal aggregate.

To this is due the superior toughness and mechanical strength of silfrax.

The commercial applications of silfrax are as refractory materials, electrical heating elements and chemical ware. It has all the chemical and heat resisting properties of carborundum and in addition great density and toughness. Heretofore the articles produced have been of small size. Pyrometer tubes are now made 24 inches in length, and by special furnace construction it will be possible to make much larger sized articles for special refractory vessels and chemical apparatus. It has not yet been determined whether the material can be produced of sufficient density to be used as acid evaporating vessels, for which its very low coefficient of expansion and high thermal conductivity specially adapt it.

In the discussion which followed Dr. C. B. Thwing asked as to the suitability of silfrax for pyrometer tubes, as they should be superior to porcelain tubes, being more refractory and better heat conductors. He asked as to their permeability for gases. Dr. Richards asked whether silicon might vaporize which would attack the couple.

Mr. Horace W. Gillett replied that he had used silfrax tubes for a pyrometer for molten brass. The silfrax tubes may be plunged into the brass without danger of cracking. But at the temperature of yellow brass the tubes are not sufficiently gas-tight to allow a satisfactory use of the pyrometer as yet. There is needed an impervious inner coating for the tubes.

The further discussion centered chiefly around Mr. Tone's new theory of the formation of carborundum and especially its fundamental assumption that carbon has no appreciable vapor tension at the furnace temperature.

Mr. F. A. J. FitzGerald did not think that this has been proven or that it is generally admitted. He described a number of interesting experiments he had made on reactions between carbon tubes with silica or silicon, inside or outside, and from them he drew the conslusion that in explaining the phenomena in a carborundum furnace it is better to work on the hypothesis that we have appreciable vapor pressures not only of silica and silicon, but of carbon and silicon carbide. In any case before that hypothesis ceases to be useful, we need more experimental evidence than has so far been disclosed.

Prof. Jos. W. Richards referred to a method for calculating approximately the vapor pressure of carbon. He finds that at 1730 deg. C. there will be as large a vapor tension of carbon as there is of zinc in the sherardizing furnace. Since in the latter case zinc is plated out commercially, there is good reason for supposing that the tension of carbon vapor can play a very appreciable part in the reaction of the carborundum furnace.

Mr. F. A. Lidbury asked whether in the paper absolute conclusions had not been drawn in cases which admit of several interpretations.

Mr. W. R. Mott thought that at the temperatures in question the vapor pressure of carbon must be extremely small, because otherwise there could be no carbon-filament incandescent lamp.

Dr. W. C. Moore suggested that the graphite tube used in one of FitzGerald's experiments might have absorbed oxygen which might have been a disturbing factor in the results.

Mr. Tone stated that according to a calculation of Sir William Crookes carbon has zero vapor tension at 2700 deg. C. Very important experimental evidence is to be found in the graphite pseudomorphs obtained in the decomposition of carborundum by heat, the silicon being vaporized and the carbon being left in a skeleton of the exact form of the original carborundum crystal. They retain not only their crystalline outline, but the markings, workings, and spirals that often occur on the faces of these crystals. Mr. Tone thought that Mr. FitzGerald's experiments were not carried out in a way so as to exclude completely oxygen.

Mr. Alfred H. Cowles referred to some early experiments made by him.

### Electrolytic Insulation of Aluminium Wire

A paper on this subject by C. E. Skinner and L. W. Chubb, of the Westinghouse Company, was read by Mr. Skinner.

Any gain in the efficiency of electric conducting material must be obtained by increasing the conductivity or decreasing the thickness of the insulation. The authors have found that it is possible to produce an insulating coating on the surface of aluminium wire which is so extremely thin that on many of the smaller sizes of wires it is possible to get a higher space efficiency, so far as the conducting material is concerned, in a coil with aluminium than with copper, even when the thinnest possible insulation is applied to the copper.

The skin or thin layer of natural oxide which is so objectionable in the soldering of aluminium is a nonconductor of high dielectric strength and the authors have developed a method of strengthening the coating by means of an electrolytic action which produces a coating of many times the dielectric strength of the coatings which has been obtained by former methods.

The various arrangements of apparatus which were devised in the development of the process are described in the paper. In the last one developed the wire passes straight through five tanks, of which the first and last contain hot water for washing and the middle three electrolyte. Solutions of borax, ammonium borate and sodium silicate are suitable electrolytes, the last being the best of the three.

The speed of treating wire varied from 40 to 150 feet per minute for the different sizes of wire used and the consumption of energy was from 0.15 to 0.80 watt hours per square inch of surface treated.

The insulation formed by the above is a thin film of alumina which is smooth and iridescent or abrasive and white. The smooth films form with a greater expenditure of energy and in inferior electrolytes. The white film formed in sodium silicate at about 425 volts is rather smooth to the touch, but so abrasive that it cuts and grinds the hand while coil winding. In some cases this treated wire running through the hand of the winder has cut through the skin and into the flesh before discovery.

The dielectric strength is far superior to the oxide coat formed by the former methods, for instead of standing a maximum of 0.5 volt two wires electrolytically treated and twisted tightly together without abrasion will stand from 200 to 500 volts.

The thickness of the film is apparently variable. Tests of change in diameter of wire before and after treating and tests of reduction in metal section by resistance measurements before and after treating show the coating to be from 0.0001 to 0.0004 inch (0.00025 to 0.001 cm.) thick.

On account of the thinness of the film it is quite flexible and does not open or appreciably weaken by sharp bends and kinks in the wire. Soft wire can be stretched 30 per cent of its length without apparently injuring the insulation. Two wires at a potential difference of 250 volts can be crossed and pressed together at the intersection until the wires are dented to such an extent that the intersection is no thicker than a single wire. If there is no relative motion between the surfaces in contact the insulation will not break down, but the slightest movement of one of the wires will cause a grinding between the surfaces which will at once cause a short circuit.

The insulating coating is fireproof and has sufficient strength mechanically to support the wire in small coils when the metal is above the melting point. Small coils run with the wire molten will fall to pieces if the current is suddenly stopped, but if the current is gradually lowered the metal will solidify and remain intact.

Electrolytically insulated aluminium wire is suitable for many classes of work requiring wires of relatively small size where the insulation requirements are not excessive and particularly where temperature requirements are severe. The very small sizes, No. 30 B & S Gauge and smaller, cannot be satisfactorily used on account of the difficulty in drawing the wire and in subsequent handling. In the very large sizes there is no advantage in the use of aluminium wire where the space is restricted. This wire has been found particularly advantageous for use in coils which require light weight and which are subject to relatively high temperatures, provided the insulation requirements on the individual wires are not excessive. The weight of an aluminium wire coil is from 40 to 50 per cent of that of the equivalent copper coil. The thermal capacities of the two types of coils are practically the same and the temperature coefficients are equal. The heat dissipation through the aluminium coil is found to be slightly better than the equivalent copper coil.

While this new wire has limitations, it has a decided sphere of usefulness, which will probably be greatly extended, particularly in the event of the ratio between the base prices of aluminium to copper being decreased.

The paper was discussed by Mr. W. R. Mott and Mr. H. M. Hall, who had used such a process on square aluminium wire. In order to get satisfactory results at the edges he had to draw the edges rather blunt; it was still square wire, but the edges were appreciably rounded. Mr. Skinner replied that it is a fundamental principle in electrical work not to use wire with sharp square edges.

### Electropercussive Welding

A paper on this subject by C. E. Skinner and L. W. Chubb, of the Westinghouse Company, was presented by Mr. Chubb.

In the development of the process of electrolytically insulating aluminium wire (described in the preceding abstract) it was found that the making of joints in the wire itself was a serious problem. It was solved by developing the process of electropercussive welding. Two wires are welded together by causing a condenser discharge to pass between the ends of the wires in the moment when they are pressed together by mechanical force.

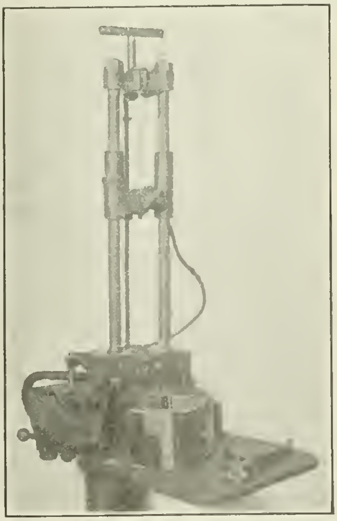


FIG. 5—APPARATUS FOR ELECTROPERCUSSIVE WELDING

Fig. 5 shows a portable tool of the gravitational type set to attach a copper lead wire to a coil of aluminium wire. The welding circuit (Fig. 6) consists of a direct-current line, or a generator *G* which charges an electrolytic condenser *C* through a high resistance *R*. Adjustment of the voltage of the charged condenser is obtained by field control of the generator or by varying the resistors *R* and *R'*. The wires *WW* to be welded are secured in the wire grips of the welding tool which are connected to the terminals of the condenser through an inductance *L* of from 2 to 10 turns of cable. A spring switch *S* with carbon contacts, normally held closed is connected across the jaws of the welder so that their potential difference will be zero while the wires are being put in or the finished product is being removed. The welder is connected to the auxiliary apparatus by means of long flexible cables which allow welding within a radius of about 50 feet without moving the condenser and without any other heavy apparatus.

The process of welding is as follows: The wires are secured in the wire grips and the ends cut off as short as possible with a suitable pair of cutters. The switch *S* is then opened which charges the condenser to the proper voltage, a catch is then released which lets the sliding member fall and bring the ends of the two wires into percussive engagement. At the instant of contact, the short circuit current of the condenser builds up to such a value that the ends of the wire are melted by the explosive discharge and instantly forged together by the blow of the falling mass. The weld is then complete and after being removed from the machine will be found to have the strength of the original wire.

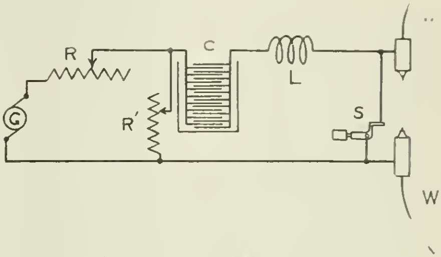


FIG. 6—ELECTROPERCUSSIVE WELDING

The generation of the heat is so localized, so sudden and so intense, that there is no time for unequal heat conduction through the shanks of the wire and the ends will be melted and even vaporized whether the melting point is high or low. For this reason metals of different kinds can be welded together independent of their electrical resistance, melting point or heat conductance. Any combination of metals which has ever been tried will weld together, but the joints will not be permanent with such combinations as aluminium and tin, or lead and iron.

Electrically the weld is complete in 0.0012 second and although 23 kilowatts are being dissipated between the ends of the wire at a certain instant, the total energy used at the weld is about 0.00000123 kilowatt-hour or enough to light an ordinary 50-watt, 16-candle-power lamp for 0.09 second.

Many of the alloys of most metals are very hard and brittle. As an example, there are alloys near both ends of the copper-aluminium series which are unworkable, and yet electro-percussive welds between these two metals are so ductile that they may be worked in a die, forged, or rolled into thin foil. Any alloy formed at the weld must range from 100 per cent copper on one side to 100 per cent aluminium on the other; but possibly the brittle combinations are so thin that the joint as a whole is flexible and ductile. This joint between aluminium and copper is of great importance, as copper lead wires, which solder and connect easily, can readily be attached to aluminium coils. At first it was feared that a diffusion of the two metals in service would finally result in a brittle joint, but tests show that after four years the joints are practically as strong and ductile as when first made. Similar ductility has been noted in almost every combination of metals when first welded, but diffusion, disintegration and loss of ductility eventually result in such welds as silver to tin, or aluminium to tin.

Metals which are either hardened or softened with heating and sudden cooling can be welded together without appreciable change in the physical properties of the material. Tempered spring steel welded, reduced to uniform diameter, and tested has shown equal or greater strength at and near the weld without any noticeable change in temper. Metals such as hard drawn copper, silver, aluminium, etc., which soften with heat can be welded together without causing any local annealing, and these metals and steel when soft can be welded together without detrimental local hardening.

This type of weld offers a very convenient specimen for the study of the diffusion of different metals at different temperatures and under various other conditions. Micrographs were given showing copper-platinum and copper-silver respectively. Both of these welds show a sharp dividing line at 1000 diameters. While the apparatus up to this time has been made only for the welding of wires, 0.072-inch diameter and smaller, the application to larger sizes is merely a question of the design of suitable apparatus.

### Electroplating

A paper by Prof. W. Lash Miller, of Toronto University, dealt with "the formation of a badly conducting film on copper anodes in copper cyanide solution."

While preparing some experiments for the laboratory of the Toronto Branch of the American Electroplaters' Society, a current of about one ampere was sent through a copper cyanide bath (No. 3, below) using strips of copper 9 cm. x 3 cm. as electrodes, the 110-volt direct-current lighting circuit as a source of current, and a 32-candlepower carbon filament lamp as resistance in the circuit. The lamp, bright at first, within a minute's time burned dim, the evolution of hydrogen at the cathode fell off, and a voltmeter set over the cell showed a potential difference of 45 volts. On examination, the anode was found to be coated with a smooth yellow-green adherent deposit; and a few simple trials soon showed that the resistance of this film was the cause of the drop in current.

The formation of such a deposit evidently sets an upper limit to the current density at the anode that can be used efficiently with any given bath; a number of solutions recommended in the literature, which had been made up for another purpose, were tested from this point of view.

It was soon found, as expected, that the current density of which a noticeable film is formed depends on the shape and position of the anode and on the amount of circulation in the electrolyte; the simple apparatus shown in Fig. 7 was then constructed, and the various electrolytes were compared under the conditions obtaining in it.

In the figure, *A* is the anode, a cylinder of copper rod 2 cm. in diameter, *C* is the cathode, a hollow cylinder of sheet copper 2 mm. thick, 4 cm. internal diameter, slit down one side so that the height of the liquid could be read on a paper scale *S* pasted on the outside of the glass container *G*. Anode and cathode were held in position by means of two corks, of which the lower, *L*, was provided with a socket to catch the end of the anode and with notches around its edge to let the solution flow out evenly when the tap was opened. The zero mark of the scale was level with the upper side of the lower cork, its graduations ran from 1 to 10, and gave the area of submerged anode in tenths of a square decimeter; division 10 was 2 or 3 centimeters below the upper cork *U*.

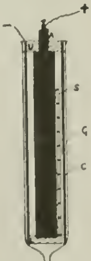


FIG. 7—TEST CELL

To ensure that the liquid would run out of the cell at the same rate in different experiments, a glass nozzle was attached by rubber below the tap, and the latter was always either closed or wide open; with the nozzle used it took the solutions 60 seconds to fall from division 10 to division 1 on the scale, the volume comprised between these two marks being 197 cc.

Before each measurment, anode and cathode were cleaned by nitric acid, washed under the tap, and placed in the container; 250 cc. of an electrolyte was poured in through the funnel, the tap was opened, and as the surface passed division 10, the current (about one ampere) was switched on and its amount recorded. As the level fell, a voltmeter wired across the cell was read; at first the voltage was low, then suddenly began to rise, often with a well marked "jump," whereupon the circuit was broken, the cap closed and the level recorded; hence the current density when the sudden rise in voltage began was calculated. If the tap were left open, and the current on, the voltage rose rapidly until the needle reached the end of the scale.

Tests were made for various solutions and the results given in a table in the paper. Sulphate and carbonate solutions with different amounts of potassium cyanide, potassium and sodium carbonate, and ammonium hydroxide were tested. As a general rule not only cyanide, but ammonia or any other substances that hold the copper in solution, can be added to the bath to permit the use of a high anodic current density.

### Electrodeposition of Lead and Tin

Prof. Frank C. Mathers, of Indiana University, presented a paper on the electrodeposition of lead from lead acetate solutions.

Lead fluosilicate and lead perchlorate baths are the only ones that have been used successfully in lead plating. The great disadvantage or objection to them is that they must be made by special apparatus and by troublesome methods. The actual electroplating with either of them is very easy.

The deposits of lead which were obtained by the electrolysis of lead acetate baths containing ammonium perchlorate and peptone were much better than had been obtained previously from any lead salt of a weak acid. The cathodes were smooth during the first part of the deposition, but as the thickness of the deposit increased the cathodes became more and more rough. All of these deposits were brittle.

As these baths lacked something, the author has now tried various additions agents and has obtained smooth, finely crystalline deposits, much superior to those obtained with peptone as addition agent.

For each liter (1.056 quarts) of bath there should be used 100 gms. lead acetate, 40 gms. ammonium perchlorate, 25 to 50 cc. of glacial acetic acid and addition substance and an addition agent for which five different prescriptions are given. The best is this:

Treat 12.5 gm. of aloes with 500 cc. of warm water and shake until the soluble material has dissolved. Let stand until the insoluble tar or gum settles and adheres to the sides of the vessel.

Dissolve the insoluble tar or gum obtained from the extraction of 12.5 gm. of aloes with water, in the glacial acetic acid. Add this solution to the bath and electrolyze without filtering. No better addition agent than this was found.

A current density of 0.4 amp. per sq. dm. (3.6 amp. per sq. ft.) must be used for thick deposits. For thin deposits in plating 0.8 amp. per sq. dm. may be used. With the higher current density, ammonium acetate cannot be used in place of the ammonium perchlorate.

The current efficiencies at the anode and at the cathode are near 100 per cent. The excellent corrosion of the anodes is proved by the fact that the copper wires attached to the anodes in the solution were not dissolved. The specific gravity of the deposited lead was 11.27.

More of the addition substance and more acetic acid must be added to the bath during the course of the electrolysis.

Prof. **FRANK C. MATHERS** then presented a second paper, written by himself jointly with **BARRETT W. COCKRUM**, on "electrodeposition of lead from lead lactate and lead formate solutions."

This paper gives the details of experiments on the conditions under which a smooth, thick, firm, crystalline but rather brittle deposit of lead can be obtained from lead lactate and lead formate baths.

The baths that gave the best deposits contained 4 per cent of lead as lactate or 2 per cent of lead formate, 1 to 5 per cent of lactic or formic acid, 4 per cent of ammonium perchlorate and 0.25 per cent of Barbadoes aloes.

This mixture was warmed and then filtered in order to remove the insoluble gum which was in the aloes.

FIG. 8—ARRANGEMENT OF FITZGERALD LABORATORIES FOR SYMPOSIUM ON PRACTICAL ELECTROCHEMISTRY

A current density of 0.4 amp. per sq. dm. (3.6 amp. per sq. ft.) was found to be best; with higher current densities the deposit became rougher.

Thick deposits were obtained without difficulty. The specific gravity of this electrodeposited lead was 11.25 and 11.28 for the lactate and formate baths respectively.

Other addition agents were tried in the place of the Barbadoes aloes, but of these peptone was the only one of any marked value.

It was found that sodium naphthalene sulfonate could be used in the place of ammonium perchlorate. Other salts of strong acids did not give as good results as the perchlorate.

The only disadvantages in the use of baths containing lead salts of weak acids are:

(*a*) A low current density must be used.

(*b*) The deposits are brittle as a result of the large amount of addition substances that must be used.

Prof. **FRANK C. MATHERS** finally presented a paper by himself and **BARRETT W. COCKRUM** on "electrodeposition of tin from tin salts of mineral acids." A very extended research was made, but a method giving an entirely satisfactory deposit has not yet been framed. New addition agents are to be tried.

Professor Mathers illustrated the presentation of his papers by various interesting samples of deposits obtained under different conditions.

Messrs. W. Lash Miller, S. S. Sadtler, Francis C. Frary, Jos. W. Richards and G. A. Roush participated in the discussion. The latter pointed out that the density of the lead deposited by Mather is lower than that of cast lead. This is the reverse of the case of copper, electrolytic copper being always higher in density than cast copper.

Prof. J. W. Richards explained that cast copper contains gases which lower its specific gravity, while cast lead does not.

### The Evaporator Problem in Electrochemical Plants

The Saturday morning session was opened by the presentation of a paper, by **OTTO MANTIUS**, on "the evaporator and the power problem in electrochemical plants." The paper is published in full elsewhere in this issue. (See p. 722.)

The paper was discussed at some length by Messrs. A. H. Hooker, L. V. Vorce and E. M. Sergeant. Mr. Vorce referred to a combination of double effect and single effect as a rather convenient form of evaporator operation which should deserve consideration.

The corrosion of the tubes was also the subject of various remarks. Mr. Hooker asked why in the vertical-tube type of evaporator the corrosion should always be in the upper parts of the tubes? If abrasion, why was it not greater in the first than in the second, since there is more salt in the former? Mr. Mantius replied that the speed increases enormously from the bottom to the top; for this reason the salt has a greater wearing action at the top of a tube than at the bottom. The top grows thinner. Also the speed is much higher in the last effect than in the first and second effect.

### Symposium on the Practical Side of Electrochemical Investigation

After the presentation and discussion of Mr. Mantius' paper the whole of Saturday was devoted to a symposium on "the practical side of electrochemical investigation," consisting of "a number of informal demonstrations of apparatus, methods, and materials used in electrochemical investigations or as electrochemical aids to chemical investigation."

FIG. 9—ELECTRIC (GRANULAR CARBON RESISTOR) FURNACE FOR HEATING COFFEE AT LUNCHEON IN TRANSFORMER SUBSTATION

This was an entirely novel undertaking and it should be stated at once that it was a full success and was thoroughly enjoyed by all who attended it.

The attendance was about 150 during the morning as well as the afternoon and the interest never flagged to the end.

The FitzGerald Laboratories where the symposium was held, are ideally suited for just such an undertaking, as they were founded and equipped not only for the development of electric-furnace and other processes (in which line the FitzGerald Laboratories have greatly distinguished themselves), but also for demonstration purposes. Excellent use was made of the power, furnace, and apparatus facilities available in this laboratory. Final success was assured by the esprit de corps of the Niagara Falls electrochemists who had stood together in the careful preparation of the symposium to make it a notable event. As a matter of fact, it went off without a hitch and proceeded exactly according to schedule.

As President Lidbury explained, one principal object of the symposium was to show how one can get along very well quite often in research work with simple home-made appliances instead of highly elaborate special apparatus.

The general procedure was that the man who would make a demonstration would first make a brief speech from the rostrum, explaining what he was going to show. Then the audience would pass over to the place where the demonstration was made, watch it, and finally return to their seats, when a general discussion would be started.

Mr. F. A. J. FitzGerald showed the heating of a carbon rod and the formation of a fused silica tube from sand placed around the carbon rod, with a convenient arrangement of four transformers which can be connected up in different ways for furnace regulation. The formation of carborundum crystals at the contact surface was observed. The matter was of interest in connection with his discussion of Mr. Tone's paper of the day before.

Mr. L. F. Saunders showed a resistance-furnace arrangement useful for melting-point determinations, the charge in the chamber being heated by radiation from a resistor at the top. This resistor is formed by a graphite plate sawed in such a way that incisions are made alternately from either side parallel to the end edges, so as to force the current to pass in a narrow zig-zag path through the plate and heat it. It is used directly on a 110-volt circuit. Such a resistor may be used for some seven or eight heats. Temperatures up to 2200 deg. C. can thus be produced.

Mr. Saunders then showed the behavior of an amorphous carbon tube in short-circuit between graphite blocks in a 50-volt circuit. When the tube heated up, the current increased to 1500 amp.

The construction of wire-wound tube and crucible laboratory furnaces with alundum as refractory was then shown, the method of winding being demonstrated by Mr. J. B. Glaze. Nichrome wire is used as resistor for temperatures up to 1000 deg. C.

Mr. FitzGerald showed a simple construction of a 50-volt 1200-amp arc furnace of the Stassano type with graphite electrodes and demonstrated in it the melting of lime. Vitrocarbon brick was used for the furnace roof.

This vitrocarbon brick is a new refractory brick of the National Carbon Co. As explained by Mr. A. T. Hinckley, this brick stands temperatures up to 2400 deg. C. in a reducing or neutral atmosphere. There is no shrinkage even at high temperatures. Vitrocarbon brick is a little cheaper than high-grade silicocarbide materials. Its heat conductivity is between that of silicon carbide brick and alundum brick. Its electric resistance is 1 ohm per inch cube, but decreases with increasing temperatures. It is an acid refractory.

Mr. Hinckley also showed a sample of a new "heat-insulating refractory brick," which has a heat conductivity 70 per cent of that of standard firebrick at 600 deg. C. and can be used up to 1400 deg. C. It cuts down the heat losses by 30 per cent.

The results of a Seger cone experiment were also shown, silicon brick cones and vitrocarbon brick cones being among the cones tested. The vitrocarbon brick had stood the test best.

Mr. Hinckley then demonstrated the method of measuring the resistance of joints of carbon electrodes screwed together, by the drop of potential method. The potential drop is measured over a length of continuous electrode and over an equal length containing a joint. A special paste of the National Carbon Company permits to reduce very much the power loss in the joint between two threaded electrodes screwed together. The resistance of the joint is equivalent to 3 or 4 in. of carbon without joint. But the use of the special paste brings this figure down to 2½ or 2 in. Rex A tool steel is suitable for shaping, drilling, etc., carbon electrodes.

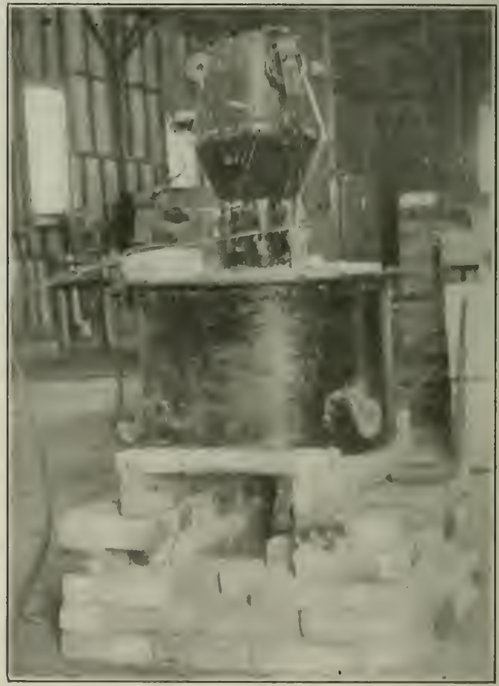


FIG. 10—ELECTRIC FURNACE FOR MELTING TIN DROSS

Mr. E. R. Cole demonstrated the great ease of machining Acheson graphite and the production of the most varied forms of graphite articles for special purposes, for instance, the production of a resistor tube by sawing a spiral curve into a graphite tube, further graphite terminals for mercury-arc rectifiers, etc.

Mr. Dantzisen showed a molybdenum-wire-wound alundum tube furnace of the General Electric Company for temperatures up to the melting point of alundum (about 1900 deg. C.). Oxidation of the wire is prevented by an atmosphere of hydrogen.

Dr. Carl Hering, of Philadelphia, Pa., showed a simple model of his pinch-effect furnace in which he demonstrated the melting of lead, the agitation produced by the "pinch effect" being clearly shown.

This was the last demonstration of the morning session.

Lunch was taken at the nearby Cliff Distributing Company's substation, where among other excellent things coffee prepared on a granular-carbon resistance furnace was greatly enjoyed. The highly original yet simple arrangement is shown in Fig. 9. For this as well as the photograph of the interior of the Fitz-Gerald Laboratories (Fig. 8) we are obliged to Mr. J. Rattray Wilson, electric engineer of Niagara Falls and an amateur photographer of no mean ability.

A visit to a nearby linen factory followed.

In the afternoon session Dr. Hering's pinch effect furnace was first the subject of some discussion. As to the temperature difference between the resistor and the bath, Dr. J. W. Richards estimated that for a viscous metal it might be 100 deg.; for brass it would be hardly 20 deg. As Dr. Hering explained, this temperature difference depends on the viscosity of the metal and also on the pinch force. Barium chloride is not suitable for direct melting in a pinch-effect furnace, but it can be easily melted over a fused bath of lead. In a pinch-effect furnace in Philadelphia a good many tons of brass have been successfully melted.

In the development of the furnace the chief trouble experienced has been with the transformer. The energy of the motion in the furnace is represented by a counter electromotive force in the circuit. This is very favorable, as it allows the use of higher voltages at the furnace and a much easier design. But as it is not known exactly in advance, it may be that it comes out differently from what was expected, and the transformer has to be redesigned. A further transformer trouble is that if regulation is wanted, the power factor is poor.

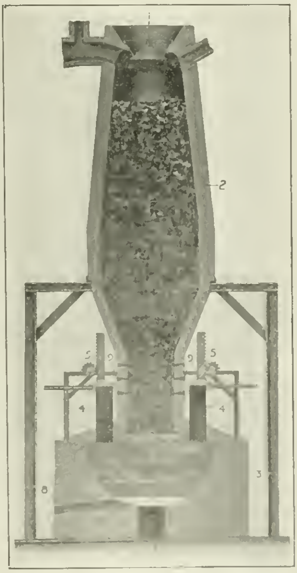


FIG. 11—TIN-DROSS ELECTRIC FURNACE

Dr. Hering stated that there is absolutely no trouble with the resistor holes. They do not wear away. They are made of fused magnesite. The pinch-effect furnace can be used for reduction processes, but slag must not be permitted to get into the resistor tubes. Metal must always stay in the resistor tubes.

Mr. L. W. Chubb then demonstrated the electro-percussive method of welding aluminium wires together, as described in the abstract of his paper given above.

Mr. Raymond S. Wile, of Pittsburgh, Pa., demonstrated his electric furnace for melting tin dross. A view of the demonstration furnace is given in Fig. 10, while Fig. 11 is a diagrammatic sketch of its construction. The charge is fed into the furnace stack 2. The construction is shown for operation with two-phase or three-phase currents, when 4 are the upper electrodes and 6 the bottom electrode. 5 is the gear mechanism for adjusting the position of the top electrode. The upper electrodes 4 do not come in contact with the tin dross being melted and their ends merely dip into the layer of slag. As slag, a layer of molten glass is used which also serves as resistor. The slag level is maintained constant by means of the overflow hole 7. The tin metal is tapped off through 8.

Most of the tin that evaporates is condensed in the column of charge coming down through the shaft. Any tin vapor which should not be condensed is recovered in a down comer. The loss of tin in the slag is only one-half per cent. The total loss by volatilization is 1½ to 2½ per cent, the actual furnace loss from ¾ to 1 per cent of the tin charge.

In the discussion which followed the demonstration Mr. Wile stated that the specific energy consumption was from 600 to 900 kw-hours per ton of tin, depending on the size of the furnace and the consumption of the slag.

Further discussion centered on the starting of the furnace and regulation of temperature. The latter may be done by a transformer with different steps or by varying the thickness of the glass layer.

The furnace has been used not only for melting tin dross, but for melting glass, also brass and other alloys, and for the melting of the precipitates in cyanide plants.

Mr. P. E. Landolt of the Research Corporation demonstrated Dr. Cottrell's electrostatic method of precipitation of dust particles from fumes. Alternating current was transformed by a special synchronous commutator to rectified direct current at 40,000 volts. The demonstration was made successfully with zinc oxide and later with phosphorus fumes.

The latter experiment demonstrated the fact that the design of the apparatus and the voltage required depends on the rate of flow of gas and the amount of dust in unit volume.

The Cottrell process is now in successful use in cement works; for fumes from slime furnaces to recover gold and silver particles (copper refineries); for tin (stannic oxide); for zinc oxides; for lead fumes (Garfield); for lead sulphide from sintering machines (Toeele, Utah); for detarring illuminating gas; for precipitating sulphuric acid mist, flower dust, carborundum dust, borax dust, etc. In the near future the cleaning of iron blast furnace gases will be taken up.

Mr. Hinckley then demonstrated a method for determining the rate of oxidation of electrode materials used for different purposes. This may be determined either at constant temperature or at constant current or at constant voltage. Mr. Hinckley's determinations were made to constant temperature.

At 1000 deg. C. electrodes of equal porosity showed the following losses in grams per square centimeter per minute:

| | |
|---|---|
| Graphitized electrodes.......... | 0.0050 |
| Electrodes for steel furnace..... | 0.0065 |
| Fine-grained electrodes......... | 0.0075 |

Mr. FitzGerald exhibited a tube furnace for melting point determinations in which the tube is embedded in granular carbon which is the resistor. This arrangement heats up less quickly than Mr. Saunders' arrangement shown in the morning, but has a longer life.

A thermoscope, using silver sulphide, was demonstrated by the FitzGerald Laboratories.

A threaded amorphous carbon electrode 20 in. by 84 in., of 1450 lb. weight, was exhibited by the National Carbon Company, the resistivity being 0.0017 ohms per inch cube.

After a hearty vote of thanks the meeting adjourned. The next meeting will be held in the spring of 1915 at Atlantic City, N. J.

## The Hall Process of Desulphurization

In view of the commercial necessity of so operating smelting plants that noxious fumes of sulphur and other elements shall not contaminate the atmosphere, metallurgical experiments along this line have been important and interesting. At the present time the elimination of sulphur dioxide is the most important problem, since other deleterious gases and solids have been pretty well controlled.

At a recent meeting of the New York Section of the Mining & Metallurgical Society of America, Mr. H. F. Wierum gave an account of what has been done with the Hall process, which aims to eliminate sulphur from sulphide ores and mattes without allowing sulphur dioxide to escape, and to recover the sulphur thus eliminated. The following excerpt is made from Mr. Wierum's address.

William A. Hall, the inventor of this process, tested his first ideas at a little place near Paris, called Levallois. He used a small brick-lined circular furnace, 18 in. or so in diameter, with a removable tile top, into which he introduced pyrites and which he heated by a very low-grade producer-gas carrying but 130 B. t. u. per cubic foot. The results obtained in this furnace were important only as an impetus to further investigations. No matter how many pounds of pyrites were treated, or how many cubic feet of gas were used, the tests resulted in a fairly complete desulphurization of the pyrites without yielding any detectable sulphur dioxide; the fumes from the discharge pipe of this furnace apparently consisted of white or yellowish-white sulphur vapor. Steam in small but unmeasured quantities was introduced with the gas through jets placed between the gas burners on the furnace.

These experiments were repeated in a similar furnace, in London, and later in Brooklyn, the gas in both cases being a city product of from 500 to 600 B. t. u. per cubic foot. The results were the same. It should be noted that in these preliminary experiments air was carefully excluded from the furnace, except such air as was blown into the burners themselves, in quantities just insufficient to burn completely the amount of gas introduced. Air was excluded in an efficient manner by maintaining a rather heavy back pressure in the furnace.

Of course, it has long been known that about one-half of the sulphur in $FeS_2$ can be distilled from it by a mere application of heat, about 1300 deg. F., being required to start the distillation effectively. The remaining one-half, however, it has always been contended, cannot be dissociated from its combination with iron, or any other base, by simple heat. With these experiments before him, Mr. Hall drew up his first patent papers and attempted his first theory in the premises, and many a pencil was set busy trying to figure out possible chemical reactions that had apparently heretofore escaped the scientific world.

### Chemical Reactions

Now it is possible to write a reaction which will account for what the eye saw during those short tests, but whether such a reaction actually takes place *I am not prepared to say*, and I trust you will all feel perfectly free to form your own opinions as to the feasibility of such combinations as the following. Let us assume first that about one atom of sulphur has been distilled by heat alone from $FeS_2$, leaving a sub-sulphide of iron, which can be roughly designated as FeS. Now comes the first chemical reaction, whereby six molecules of FeS added to six molecules of $H_2O$ at a suitable temperature are supposed to yield six molecules of FeO and six of $H_2S$. Doubts probably arise at once in your minds as to the ability of any heat obtainable in a roasting furnace to decompose water in this manner. Nevertheless, here was this little furnace—with an air supply insufficient even to burn completely the gaseous fuel used—turning $FeS_2$ into $Fe_3O_4$, and having only the oxygen of *water* available as a stable equivalent for the sulphur in combination with iron. Red-hot iron decomposes water; why not red-hot FeS, or $Fe_6S_7$, or carbon, or red-hot *anything* that we do not know positively will *not* do it? Such were the questions we had to ask ourselves. So we go bravely on, and accuse the little furnace of decomposing enough water to satisfy the second reaction of the cycle: $6FeO + 3O = 3Fe_2O_3$. Following this comes the third chemical process, which I think is quite feasible under suitable conditions, provided the two foregoing reactions can be brought about: $3Fe_2O_3 + 6H_2S$ (if formed) $+ 5O = 2Fe_3O_4 + 6H_2O + 6S$ (free).

It seems fruitless, however, to discuss whether or not any such cycle of reactions actually occurs. I simply wish at this point to leave in your minds one fact, that in the little furnace described above, $FeS_2$, carrying some 48 per cent of sulphur, *was* freed from its sulphur, down to about 5 per cent, by a treatment with producer gas at a temperature of about 800 deg. C., introduced with insufficient air to burn this producer gas completely, and with some steam present, while maintaining such a strong back pressure that no suction whatever existed in the furnace, and no outside air could possibly have been drawn in.

The next step was the construction of a slightly larger furnace, mechanically rabbled, but of the same general design as the little pots just described. The only information gained by this increase in size and efficiency was to obtain a record as to how long the ore was under treatment, and very accurate and continuous data as to the amount of $SO_2$ in the fumes. The result of official tests conducted by two of our most respected and experienced chemists and metallurgists indicated that $SO_2$ was always below 0.1 per cent; that sulphur in the calcines was 3 per cent or under, and that the weight of ore treated per square foot of hearth area per 24 hours was approximately the same as in the regular MacDougal furnace.

Another point was tested in this second furnace. Some chemically pure sulphide of iron was bought, answering the formula of FeS. This contained no feeble atom of sulphur, nor unstable atom, or whatever you wish to call it, and yet this material was decomposed under exactly the same conditions as the pyrites, with practically identical results. In our later trials, this experience with monosulphide of iron, and also with some matte—which roughly answers the formula of monosulphide of iron—has always puzzled me and still does so.

### Commercial Experiments

When the tests had reached this point, I was called upon to carry out certain experiments that had been arranged by the gentlemen controlling the rights to this process, at a large smelter in California which had been closed down for some time. As you see, I had rather meagre data for the quipment of a unit to handle 25 or 30 tons of ore a day when the largest scale upon which the process had been tried so far had been about 25 or 30 pounds a day. I was unfortunately much pressed for time, under existing conditions, and had to attempt the impossible in getting a gas plant built, a furnace equipped, and tests completed within three months. It was found necessary to extend the time to be devoted to the tests; when this was arranged the gas plant was put in excellent shape, with washers and a fairly large gas holder, so that we we started up again, about the first of the year, we had good clean gas to use. During this second construction period we equipped a second MacDougal furnace with oil burners. Strangely enough, the totally unsatisfactory tests which we had made with oil burners in Brooklyn led us to believe that raw oil was not a suitable fuel for our purpose, and therefore the equipment of a furnace with oil burners was undertaken simply as a side show, so to speak. This furnace later proved more valuable to us and to our knowledge of the process than did the gas-fired furnace.

About the first of January we started up the gas-fired furnace, but unfortunately were unable to keep it operating for 24 hours at a stretch during the whole month—not because of any difficulty with the plant or process, but because storm after storm interrupted the power communication of the plant. These interruptions occurred on an average of twice a day for the first two weeks of January, and nearly once a day for the last two weeks. Meantime, however, our oil-fired furnace was made ready, and we seized one occasion when the shut-down was more prolonged than usual, to put it into operation, having hastily provided steam power for most of our requirements. The early part of February, therefore, we started to run the oil-fired furnace. Although still subjected to many interruptions, we gradually eliminated these, and as the weather became kinder to us, after a week or so we began to feel that we knew what to do.

The ore which we had to treat was crushed to ½ in. and as it was not in the slightest degree friable, and was very dense, ½-in. pieces were distinctly found to be too big. Therefore, a system of screen analysis was adopted on the calcines, and while our sulphur elimination from the material which passed the 10-mesh screen seemed to improve from day to day, nevertheless we found it extremely difficult to roast the ore down to the 5 per cent point which we aimed at under the conditions which we first imposed upon the furnace.

Careful analyses were made of the atmosphere existing on every hearth of this 18-ft. MacDougal furnace, and in the flue leading from it. For the first two weeks we devoted ourselves to tests in an atmosphere containing 1 per cent or less of free oxygen and rather generous percentage of CO; in other words, a highly reducing atmosphere throughout. Under these conditions we failed to get a better calcination than to about 11 or 12 per cent sulphur in the 10-mesh material. The larger pieces of ore, as they came from the furnace, were barely singed, and contained about 26 per cent sulphur, the original ore having averaged roughly 40 per cent. In all this period, hardly a trace of $SO_2$ existed in our escaping gases.

Time was again pressing and I found it impossible to try all the variations which I would have liked to try under these completely reducing conditions in the furnace. I therefore began slowly to allow a little oxidation to occur on the lower two hearths of the furnace, and while so doing we finally hit upon a set of conditions which seemed economically very important to the industry and to the problem of fume destruction. Let me state briefly what our best results were, maintained constantly for several days, and you will be able to judge whether or not we have reason to hope for important commercial developments in this process.

### Experimental Results

For about a week we fed at the rate of 24 tons in twenty-four hours. During this period the sulphur remaining in the 10-mesh calcines averaged 5½ per cent. The sulphur remaining in the total sample, of ½-in. material, coarse and fine together, averaged about 8.8 per cent. Oil consumption was 22 gal. per ton of ore, the oil being a very cheap material carrying 25 per cent of asphalt and of about 23 deg. Bé. gravity. The $SO_2$ in the fumes escaping from the furnace for the entire period was a trifle over 0.3 per cent. Labor required is practically the same as for ordinary MacDougal roasting, and, of course, the more furnaces and the larger tonnage treated, the lower the labor cost per ton, inasmuch as it takes just as many men to tend and feed one furnace as four. Please note that although the figures just given you are the averages of hundreds of samples of gas and calcines, the entire period showed improvement toward the end, and gave us an opportunity to study what changes in the furnace itself would conduce to still more favorable results. Our best results, maintained for twenty-four or forty-eight hours, towards the end of this period, may be stated briefly thus: Oil consumption 16 gal. to 17 gal. per ton of ore; 10-mesh calcines, 5.3 per cent sulphur (although for two or three days the calcines ran between 2.8 and 3.6 per cent sulphur); $SO_2$ frequently as low as 0.06 per cent, so low, in fact, that we got tired of titrating to an end point in a very weak iodine solution.

I trust you will all bear in mind that these tests were made in an existing furnace in which all mechanical arrangements, such as speed, angle of rabble blades, depth of the bed of ore, and length of time in the furnace, had all been fixed for conventional pyrites roasting operation, whence it is not surprising that some of these conditions demanded amendment to give the best results for quite a different operation. Such amendments, I am sorry to say, were beyond our possibilities in the short time at our disposal, and our metallurgical common sense must therefore come to our help in predetermining roughly what effect certain changes will have. I think that with 10-mesh ore, and with arrangements for more frequent rabbling, and for keeping the ore in certain portions of the furnace a greater length of time than the present conventional practice provides, we can maintain without difficulty the following results. In an 18-ft. MacDougal furnace I believe we can treat 40 tons of 10-mesh ore daily with 500 gal. of oil, roasting it down to 5 per cent of sulphur, and controlling the $SO_2$ fumes so that they shall never exceed 0.3 per cent, and probably average 0.15 per cent or less. You understand that these figures have not been attained, but that I am giving them simply as my opinion as to what can be attained in time.

Now for a word or two about the chemical reactions. In the upper portion of the furnace about one-half of the sulphur is distilled by heat alone. The very lowest portion of the furnace, say one-third of the hearth area, is devoted to the oxidation of iron, copper and remaining sulphur, by a free admission of air. In the middle third of the furnace a strongly reducing atmosphere and rather high temperature, say 1500 deg. F., are maintained, and it is in this central portion of the furnace that the $SO_2$ formed below is broken up and reduced to elemental sulphur. It is an undeniable fact that some $H_2S$ is formed in the upper regions, and it is equally undeniable that $H_2S$ will react upon $SO_2$ under certain conditions, forming water and sulphur, but I have not been able to prove that the $H_2S — SO_2$ reaction is the controlling feature in the reduction of $SO_2$. When a too heavily reducing atmosphere is permitted in the presence of liberated elemental sulphur and steam, certain undetermined organic sulphides are formed which seriously interfere with the production of sulphur. There seem to be two ways of preventing this interference: first, avoiding too great an excess of fuel; second, a quick drop in the atmosphere at the point where these excess oil vapors and free sulphur exist. Naturally, the former is the more economical way, but both have proved feasible.

### Methods of Sulphur Recovery

We provided a Feld washing machine to clean the elemental surphur from the gases, and for the first two or three hours after a free discharge of sulphur had been secured from the furnace, it looked as though this machine would take care of the sulphur most effectively; but, if my memory serves, four or five hours' creamy emulsion that came from the washer was led into tanks which had filter bottoms, the filtrate from which was beautifully clear and free from sulphur. Presently a disturbance appeared in the draft of the furnace, and investigation proved it to be caused by a complete clogging of all the gas passages in the washer. Fortunately we had provided facilities for by-passing the gases around the washer, and allowing them to escape from the stack into the air. This we did, and upon opening the washer found it completely clogged with yellow and gray sulphur, so sticky and plastic that neither a stream of water under high pressure nor a jet of steam would remove it from the interior surfaces.

Those who are familiar with the construction of a Feld washer will appreciate how impossible it was to clean the inaccessible spaces between the lead cones when once stuck up with this plastic mixture. After this first experience, we were able to use the washer for only an hour or so at a time, and then very ineffectively. Most of the time our gases, which consisted of a thick, heavy, yellow cloud of sulphur, were discharged through a fan to the stack and thence out into the atmosphere. Innocuous, it is true, but tantalizingly uneconomical.

To the small furnace in Brooklyn, we had previously attached a treater of the Cottrell precipitation type, and found that this electrolytic discharge was completely efficient in knocking down the sulphur. Unfortunately, business arrangements could not be made in the time at our disposal to install a Cottrell precipitation plant in connection with our MacDougal trials in California, so that until very recently I have been unable to say positively how well the liberated sulphur can be recovered. Our experience indicates that the current completely eliminated all solid sulphur from the gases, and I and most of my associates are reasonably sure that this method will prove both economical and efficient; it goes without saying that much experimentation will be required before satisfactory plant details can be worked out.

While looking into certain matters in Hungary about two months ago, I happened upon a Government sulphur factory which had been in operation for many years at a little place in Transylvania called Zalatna. I was interested to see with what facility the elemental sulphur was washed out of the gases in simple and inexpensive wooden towers containing many baffle boards over which a saturated solution of chloride of lime was flowing. The consumption of chloride of lime was almost nil; the emulsion coming from the foot of the towers was led into a series of tanks where the sulphur settled out quite completely without any filtering, and the clarified chloride of lime solution was again pumped to the top of the towers.

Naturally this suggestion seems a cheap way of solving our problem; I had three towers all half built in London, with the object of duplicating the performance which I witnessed in Hungary, when the war broke out and all business was stopped. Arrangements had about been perfected whereby I was to erect a plant in the northern part of Norway, similar to the one with which I experimented in California, but the war has also put a complete stop to that, so that our Hall process has had ill luck thus far.

In the discussion following Mr. Wierum's address, he gave the following information.

"The upper portion of the furnace is under a nearly continuous back pressure, that is, the upper two hearths. The third hearth has no pressure. The fourth, fifth and sixth hearths have a slight suction, increasing, of course, at the bottom. This suction amounts to about 4 mm of water. On the hearths where there is a suction we can use any of the ordinary types of oil burners, and rely upon an aspirating effect to draw in enough air to burn the oil; but on the upper hearths, where there is a back pressure, you cannot burn oil in any of the conventional burners. I got my idea of a burner for that condition from Mr. Peabody, who has invented a burner which is used in the United States navy. This burner relies upon the pressure of the oil to atomize it; the oil at 40 to 60 lb. pressure is led through a very tortuous passage, and is finally discharged through a very small hole. This little jet is in the middle of a 4-in. pipe, through which comes the supply of air for combustion, being delivered from a fan at a pressure of about 4 in., a very small pressure. The burner is very cleverly arranged so that the direction of the air is inward and the direction of the sprayed oil is outward, so that the two counteract one another and produce a distinctly local ignition of the oil. So far as I know, this is the only burner that will maintain any desired temperature against a back pressure, and in an atmosphere containing no oxygen."

* * * * * *

"The net result is that we have every reason to believe that it should be worth anybody's while to go ahead and finish these tests, at any reasonable cost, if he is interested in destroying sulphur fumes.

"I have always contended that it is a mistake to apply this process to any undertaking which requires close reckoning to figure out a profit. But at such operations as those in the Ural Mountains, or in Norway, or at Coram, at all of which places they have fairly cheap fuel and sulphur going to waste, with complaints about $SO_2$, there is no question in my mind that the salvage in sulphur would give you your roasting absolutely free, and eliminate the nuisance. But until we know that a profit can be made, and exactly how all details finally work out, I would not like to recommend anybody's installing it, for instance, in treating low-grade pyrites where the sulphur must be paid for in the first place.

"The cost of unpurified sulphur, with oil at 2.7 cents per gallon, figured out roughly at $4.75 per short ton; to that must be added about $3.50 for refining, because I do not believe that this sulphur is pure enough to sell to acid works."

---

## Chemical Resources of California

BY SAMUEL H. DOLBEAR

A good deal has been said and written in the last few weeks in answer to the question, "What is the American manufacturer to do now that his supply of European commodities has been cut off?" Unless this question can be solved quickly, many of our industries, some of which have already suffered, will be badly crippled.

In reading what has been offered by various writers in the technical journals, it has appeared to me that the importance of some of our own natural chemical resources has not been fully appreciated. In fact, mention of them, has in some cases been entirely omitted. I find, for example, the suggestion that some substitute will need be found for magnesite and that potash may be entirely eliminated for the present from fertilizing mixes.

Having made a rather careful study of the chemical mineral deposits of California, I take the liberty of offering a few facts concerning the more important of these in the hope that it may assist in some measure in the solution of the case before us. The United States Geological Survey has published much information of value to chemical manufacturers and users, and these publications may be obtained in most cases for the asking.

FIG. 1—MAGNESITE MINE AND CALCINING PLANT, FRESNO COUNTY, CALIFORNIA

*Magnesite.*—This material occurs abundantly in California and several deposits have been equipped with calcination plants; two or three are now producing and another is expected to resume operations within a few days. Prices have advanced sufficiently in this commodity to enable the producers to ship to the Atlantic seaboard since the European conflict arose, and with a market once created, it is believed that California magnesite may be handled profitably under normal conditions via the Panama Canal.

FIG. 2—CHROMIC IRON DEPOSIT, FRESNO COUNTY, CALIFORNIA

*Quicksilver.*—Importations of quicksilver vary remarkably as in 1906 only 84 lb. were brought into the United States, while in 1911 there was imported nearly 472,000 lb. according to the figures of the United States Geological Survey. California has many producing mines, the total production of which to date has been about 2,160,000 flasks of 75 lb. each. Of late years exports have dropped off rapidly from 13,534 flasks in 1905 to 310 flasks in 1910. It is apparent then that our own production finds a market at home and that we are dependent upon European producers for only about 25 per cent of our consumption.

The high prices recently prevailing have brought about much activity in this direction and it is not likely that the mines of California, Nevada, and Texas will experience any difficulty in supplying the demand.

*Chrome Ore.*—Chrome ore has been produced in California to the extent of about 40,000 tons. The largest production occurred prior to 1895, the decrease having been due to several causes, principal of which was the competition from New Caledonian and other deposits. Of late years the American production, which has come almost entirely from California, has been but a few hundred tons per year. With the stimulus of necessity, higher prices and lower freight rates through the canal, there is every reason to believe that activity in this material will result.

FIG. 3—PLANT OF CALIFORNIA TRONA COMPANY, SEARLES LAKE, CAL.

*Manganese Ore.*—There are numerous deposits of manganese in California and it is also found in Nevada and other Western States. Two of the California deposits are of easy access and one is within a freight rate of about $1 to seaboard. By exercising a little care in the mining and selection of this ore, a grade of 75 to 80 per cent $MnO_2$ may be maintained. Varying amounts of manganese ore have been shipped from California in the past years, the total production amounting to about 13,000 tons. It is entirely possible from a point of cost for California to supply such manganese ore as is used in the West and Central West in the ceramic arts, manufacture of dry and Leblanc cells, etc., under normal conditions. All that seems necessary to insure such production is new blood and sufficient capital to handle the industry.

*Ferro-Manganese.*—The Noble Electric Steel Company, at Heroult, Cal., is now equipping two of its furnaces, preparatory to producing this alloy. Others are also investigating the field with a view to its manufacture.

*Pumice.*—The volcanic regions of California are very extensive and large quantities of pumice are found in the State. On account of its abundance, it has found new fields, such as its use in concrete building construction. The resultant concrete is so much lighter than that in which crushed rock is used that a substantial saving in structural steel is effected. From the abrasive point of view, some of the California pumice is equal in quality to that of the Lapari Islands.

*Baryte.*—I do not know that the European war will result in any great shortage of this product as the American production is far in excess of its importations. Baryte is found in various parts of California and Nevada, and a series of experiments in the production of barium compounds has been carried on in a manufacturing plant near Oakland. It is stated that production on a considerable scale will be commenced shortly.

*Flint Pebbles.*—So far as I know, the entire Californian production of pebbles has been used heretofore within the State. Suitable shapes have been found and while the hardness is not quite that of the European variety, they have given very satisfactory service in cement mills. Most of them are a quartz rather than flint but are regarded as flint pebbles by the trade. What are undoubtedly large deposits have remained undeveloped. In a number of cases there are close to rail and readily accessible. I mention this subject as many of the American grinding plants depend on Belgium and other European countries for their pebbles.

*Mineral Colors.*—This is a rather indefinite term, and the deposits in California which may, for convenience, be classed as "mineral colors" include a great variety of minerals and a greater variety of colors. In Arizona and Nevada there are also occurrences of this character. Efforts have been made to operate only a few of such deposits, the ochres having found the largest market. A properly equipped plant, capable of receiving the crude ore and turning out a product satisfactory to the trade would, without question, greatly advance this industry.

*Alkalines.*—In this connection I desire to call attention principally to the potassium salts as the suggestion has been made that it would likely be necessary to eliminate potash from fertilizing preparations entirely for the present, with a mention of the possibility of obtaining some relief from the preparation of kelp and from alunite, felspar, etc.

At Searles Lake, in San Bernardino County, California, the discovery of potash in the alkaline deposit previously assumed to be chiefly valuable for its sodium carbonate content has attracted widespread attention. The available potash has been estimated at 30,000,000 tons. The United States Geological Survey and the Bureau of Soils originally laying claim to its discovery, were quite enthusiastic in the announcement of its discovery, but since it has been shown that the discovery of the presence of this important salt was the result of private investigation and was known some eight months prior to the departmental investigation, much space has been devoted to the possibility of finding undiscovered resources and the suggestion that it may be recovered from igneous and other rocks in which it is known to occur in an unsoluble state. A good description of this deposit may be found in the *Engineering and Mining Journal* of Feb. 1, 1913.*

*Conclusion.*—The items I have mentioned in the foregoing are but a few of the products which may be brought to account directly or indirectly in the present unusual conditions. The production of some of the salts of these elements, as is the case with magnesium chloride, is receiving serious consideration at this time. This latter is a source of great concern among those who require it, prices having advanced on the Pacific Coast from \$22.50 per ton to \$60 per ton. Experiments are being carried on along three different lines: (1) that of the direct manufacture of $MgCl_2$ from magnesite. (2) that involving the use of dolomite, and (3) through fractional crystallization of the bitter brines from the salt works, which brines are known to carry as high as 17.8 per cent $MgCl_2$ at 30 deg. Baumè. With the advent of local potash production, the manufacture of its chromium salts, as well as metallurgical chrome compounds may result.

With the development of the chemical industry in California, increased production from other of its mineral resources may be expected. If the war in Europe be long protracted, California may be expected to play a most important part in the solution of some of the problems now confronting the manufacturers of this country.

San Francisco, Cal.

# The Evaporator and the Power Problem in Electrochemical Plants*

BY OTTO MANTIUS

The electrolysis of sodium or potassium chloride solutions will produce liquors which with very few exceptions cannot be used or marketed without further concentration. In most cases considerable quantities of water have to be removed, and it is generally acknowledged that the cost for fuel, labor, repairs, interest and depreciation to be charged to the evaporating equipment have considerable influence on the rentability of the whole plant.

During the last few months we have heard a great deal about the conditions under which reciprocating engines, steam turbines or water power can be used for the generation of electric current to best advantage. In this paper I shall present some of the factors and conditions which should be considered when laying out an electrochemical plant where an evaporating system has to work in connection with water power or steam plant.

I shall not attempt to discuss the efficiency of the great variety of cells which are in daily use for the manufacture of caustic liquors, as the figures given below can readily be changed and discounted for any particular system. I shall not go into the question whether water, gas or steam should be used to produce the electric current. I shall restrict myself entirely to the discussion of those features and conditions which have a bearing on the design of the evaporating equipment.

The installation of an evaporator would be a very simple matter if we had to deal with sugar juice, black liquor or packing-house tank water. A double or triple effect for small quantities and a quadruple effect for larger amounts of liquor could be bought, installed and operated at comparatively low first cost and running expenses. The problem of a caustic liquor evaporator is somewhat complicated by the incrustations of the tubes, the corrosive action of the liquor itself and the high boiling point of the more concentrated solution, which practically eliminates the use of a quadruple effect even for large quantities, restricts the operation of a triple effect to certain favorable conditions, and makes a double effect the most economical equipment for a plant of medium capacity.

Inasmuch as this statement is quite contrary to ordinary practice, I give on p. 723 the figures for steam consumption of various equipments, which will explain and prove my contention.

My calculation has been based on the following assumptions:

---

*"Searles Lake Potash Deposit," by C. E. Dolbear

*A paper read at the Niagara Falls meeting of the American Electrochemical Society on October 3, 1914.

| | |
|---|---|
| Capacity in 24 hours | 20,000 lb. (9091 kg) NaOH. |
| Power required | 1500 electric horse-power. |
| Weak liquor | 20,000 gal. (75,750 liters) with 120 grams NaOH and 100 grams NaCl per liter. |
| Heavy liquor | 3440 gal. (13,200 liters) with 700 grams NaOH and 16 grams NaCl per liter. |
| Evaporation | 16,560 gal. (62,650 liters) in 20 hours = 828 gal. (3135 liters) per hour. |

The hourly steam consumption, including radiation loss, preheating of the weak liquor from 70° F. (21° C.) and evaporation of the wash water, will be as follows:

Single Effect—7900 lb.; 6000 lb. direct steam, 1900 lb. exhaust from pumps (3590; 2727 and 863 kg.).
Double Effect—5090 lb.; 3690 lb. direct steam, 1400 lb. exhaust from pumps (2312; 1676 and 636 kg.).
Triple Effect—4600 lb.; 3400 lb. direct steam, 1200 lb. exhaust from pumps (2090; 1544 and 546 kg.).
Triple Effect and Single Effect—4300 lb.; 3000 lb. direct steam 1300 lb. exhaust from pumps (1952; 1362 and 590 kg.).

Single effect and double effect are to be operated with steam at 7-lb. and 20-lb. gauge pressure (0.5 and 1.3 kg. per sq. cm.), triple effect at from 60 lb. to 70 lb. (4 to 4.7 kg. per sq. cm.) and the combination triple effect and single effect with steam at from 7 lb. to 20 lb. (0.5 to 1.3 kg. per sq. cm.). In the latter arrangement the triple effect concentrates the weak liquor to about 400 grams per liter, and the single effect finishes the process to 700 grams NaOH per liter. This arrangement will permit the use of low-pressure steam, and should always be used where larger quantities of liquor have to be handled.

The above figures show that the efficiency of the evaporator increases with the number of effects as usual, even if the difference is not as large as might be expected from general practice. The comparatively high steam consumption of the high pressure straight triple effect is due to the increased radiation losses and the large amount of wash waters to be handled and preheating to be done.

These conditions will change as soon as we use a part or all of the exhaust steam of engines or turbines for the evaporation of the caustic liquors.

Where the electricity for the cells has to be generated in a steam plant, either steam turbines or reciprocating engines may be used and the exhaust utilized in the evaporator. As the quantity of steam required for power purposes is about three times larger than the amount needed for the evaporator, the ordinary method of using all the engine exhaust at about 5 lb. (0.3 kg. per sq. cm.) pressure for the concentration of the caustic liquor can only be applied in very small plants by running the evaporator about 7 hours per day and operating the engine during the rest of the time in connection with the condenser attached to the evaporator.

In most cases it is necessary to run a multiple effect evaporator continuously and utilize only a part of the steam, which has entered the engine or turbine at high pressure and is withdrawn at from 20 lb. to 30 lb. (1.3 to 2.0 kg. per sq. cm.). I find that for this kind of work steam turbines are not quite as suitable as reciprocating compound engines, as in a steam turbine a large part of the work is done during the low pressure period. While actual tests on small compound engines show that 10 lb. (4.5 kg.) steam withdrawn from the receiver at 20 lb. (9.1 kg. per sq. cm.) pressure require only from 5 lb. to 6 lb. (2.25 to 2.75 kg.) extra steam at 125 lb. (8.3 kg. per sq. cm.) pressure, the guarantees given for large steam turbines ask for 8 lb. (3.6 kg.) extra steam at 150 lb. (10 kg. per sq. cm.) pressure added for 10 lb. (4.5 kg.) steam withdrawn at 20 lb. (1.3 kg. per sq. cm.) pressure.

To produce 20,000 lb. (9091 kg.) NaOH in 24 hours the steam plant should develop 1500 electric horsepower. A compound condensing Corliss engine will use 15 lb. (6.8 kg.) steam per electric horsepower per hour and increase its steam consumption 1 lb. (0.45 kg.) for every 2 lb. 0.91 kg.) discharged from the receiver at 20 lb. (9.1 kg.) pressure or higher.

Assuming that 1 ton of coal furnishes 15,000 lb. (6820 kg.) of dry steam at a cost of $3, i.e., 1000 lb. (454 kg.) of steam for $0.20, the steam and coal consumption of engine and evaporator combined will then be as follows:

*Single Effect.*

| | | |
|---|---|---|
| Engine | 1500 × 15 × 24 = | 540,000 lb. (245,300 kg) steam |
| Evaporator | 3000 × 20 = | 60,000 lb. ( 27,270 kg) steam |
| Pumps | 1900 × 20 = | 38,000 lb. ( 17,270 kg) steam |
| | | 638,000 lb. (289,840 kg) steam |

Fuel cost per day = $127.60; per 1000 lb. (454 kg) NaOH = $6.38.

*Double Effect.*

| | | |
|---|---|---|
| Engine | 1500 × 15 × 24 = | 540,000 lb. (245,300 kg) steam |
| Evaporator | 1845 × 20 = | 36,900 lb. ( 16,760 kg) steam |
| Pumps | 1400 × 20 = | 28,000 lb. ( 13,330 kg) steam |
| | | 604,900 lb. (275,390 kg) steam |

Fuel cost per day = $120.98; per 1000 lb. (454 kg) NaOH = $6.05.

*Triple Effect and Single Effect.*

| | | |
|---|---|---|
| Engine | 1500 × 15 × 24 = | 540,000 lb. (245,300 kg) steam |
| Evaporator | 1500 × 20 = | 30,000 lb. ( 13,635 kg) steam |
| Pumps | 1300 × 20 = | 26,000 lb. ( 11,820 kg) steam |
| | | 596,000 lb. (270,755 kg) steam |

Fuel cost per day = $119.20; per 1000 lb. (454 kg) NaOH = $5.96.

A straight triple effect naturally cannot be operated on steam of 20 lb. (1.3 kg. per sq. cm.) pressure, and live steam has to be used altogether.

*Triple Effect.*

| | | |
|---|---|---|
| Engine | 1500 × 15 × 24 = | 540,000 lb. (245,300 kg) steam |
| Evaporator | 3400 × 20 = | 68,000 lb. ( 30,900 kg) steam |
| Pumps | 1200 × 20 = | 24,000 lb. ( 10,900 kg) steam |
| | | 632,000 lb. (287,100 kg) steam |

Fuel cost per day = $126.40; per 1000 lb. (454 kg) NaOH = $6.32.

In all cases evaporators and pumps work only 20 hours per day, while the cells are naturally operated during the full 24 hours.

These figures show that for a production of 3600 tons caustic per year the cost of fuel is about $2,000 higher for a straight triple effect than for a double effect or combination triple and single effect. Besides, we must not forget that a high-pressure triple effect is considerably more expensive in first cost and repairs, and is sometimes difficult and even dangerous to operate. Wherever possible, evaporators for caustic liquors of high density should be operated under vacuum, as it will prevent loss of caustic and reduce the corrosive action of the liquor.

Quite a number of electrochemical plants obtain the necessary power at very low rates from central power plants, but have to install boilers to furnish steam for the evaporators. At first glance it would appear that a high-pressure triple effect might be the most economical equipment, but the following figures will prove that as far as cost of power is concerned a different arrangement is preferable. Let us assume that only $22 is charged for 1 electric horse-power per year and that 1000 lb. (454 kg.) steam cost $0.20 as before.

*Straight Triple Effect.*

| | | |
|---|---|---|
| Cost of energy | $\frac{1500 \times 22}{365} =$ | $90.40 |
| Evaporator and pumps | 4600 × 20 = 92,000 lb. = | 18.40 |
| | | $108.80 |

Therefore 1000 lb. (454 kg) NaOH = $5.44.

We have seen before that a combination triple and single effect can be operated at low pressure and uses less steam than a stright triple effect. We can, therefore, first use the high-pressure steam in a special compound engine to furnish a certain amount of power at not any cost for fuel, and then utilize the exhaust for the evaporation of the liquor. Assuming that the engine will use 23 lb. (10.5 kg.) per hour per electric horsepower, and therefore produce 130 electric horsepower from the available 3000 lb. (1364 kg.), we have only to purchase 1370 electric horsepower, outside power, and the cost will be as follows:

*Combination Triple and Single Effect.*

| | | |
|---|---|---|
| Energy | $\frac{1370 \times 22}{365} =$ | $82.60 |
| Engine and evaporator | $130 \times 23 \times 24 = 72{,}000 =$ | 14.40 |
| Pumps | $1300 \times 20 = 26{,}000 =$ | 5.20 |
| | | $102.20 |

1000 lb. (454 kg) NaOH = $5.11.

This would mean a saving of over $2,400 per year, less interest, depreciation and repairs of engine. Quite frequently it might not be desirable to install such an engine, but there will always be a number of pumps and small engines the exhaust of which should be used in the evaporating equipment.

We could even go a step further and in stall a 500-hp. compound condensing engine, use in the evaporator steam taken from the receiver and contract for only 1000 hp. to be taken from the central station. Considering the cost of extra labor, repairs and depreciation, we would not save much, but the engine could be arranged so as to take up the peak load, for which otherwise in most cases heavy penalties have to be paid, and the plant could be operated at two-thirds of its normal capacity by shutting down the engine without having to pay for more than the 1000 hp. Besides, the plant has not to be closed down entirely in case the central plant should not be able to furnish the current.

Similar conditions prevail in plants where gas engines or heavy oil engines are used to generate the current for the cells. A double effect or combination triple and single effect using exhaust steam from auxiliary engines and pumps will give the best results.

A type of engine used very little in this country is the Lentz patented superheated steam engine, which even in small units will produce current at surprisingly low cost. I was told last year during a visit to Germany that 1 electric horsepower hour can be produced by 10 lb. (4.5 kg.) of steam and less in a 300-kw. unit. This would make the Lentz engine the ideal motive power for small plants furnishing bleach liquor and caustic for paper mills.

The foregoing figures lead to the conclusion that a straight triple effect operated with high-pressure steam should never be used for the concentration of caustic liquors. The first cost is high, and the expenses for fuel, repairs and renewal are more than for any other arrangement. Besides, such a triple effect is considered by many people a general nuisance and source of trouble on account of the difficulties in keeping joints and valves tight.

As far as the cost of fuel per 1000 lb. (454 kg.) NaOH is concerned, there is not much difference between a single, double or combination triple and single effect, but low first cost and simplicity of operation should induce us to choose a single or double effect for small capacities up to 5 tons NaOH per day; for larger plants, and especially where the cost of coal is high, and large amounts of cooling water can be had at only considerable expense, a double effect or combination triple and single effect should be installed. The proper arrangement has to be determined for each plant, and no general rules can be given.

I wish to add a few words concerning the general design of the evaporating equipment:

1. For small single effects operating only 10 hours per day no reserve is needed, as all repairs can be done over night. The piping of multiple effects running continually should always be arranged so that any pan can be cut off entirely for repairs.

2. Steel, charcoal iron or nickel steel tubes should be used only up to 40° Bé., as the corrosive action of caustic up to this density is very small, and any kind of tube will last a long time, unless the liquor contains a considerable amount of corrosive impurities.

3. For the concentration from 40° to 50° Bé. and higher, only special cast-iron tubes should be used, because cast iron is the only material that will withstand the action of the hot concentrated caustic liquor. In Germany almost all the caustic liquor above 40° Bé. is handled in cast-iron evaporators. The first cost of such an equipment is somewhat higher, but this difference is soon paid for by the saving in repairs and the increased efficiency of the plant, as there is no time lost in shutting down to replace worn-out tubes. Some of the largest manufacturers of caustic in this country prefer to use copper tubes almost exclusively, as copper will wear longer and more uniform than steel or charcoal iron. Besides, the scrap value of the discarded tubes is quite high. On the other hand, the first cost is considerable, and where large amounts of salt have to be handled the copper tube disappears quickly on account of the mechanical abrasion caused by the salt passing along the copper surface at high speed.

It was not my intention to consider all possible combinations between evaporator and the source of power, as this is not the time and the place to make such an exhaustive investigation. I only wished to point out the economic and practical disadvantage of a high-pressure straight triple effect when handling caustic liquor up to 50° Bé., and the good results that may be obtained from a compound or triplex condensing engine when working in connection with a double effect evaporator or a combination of low-pressure triple effect and single effect with a cast-iron heating surface.

Buffalo, N. Y.

---

## Electro-Chemistry and Metallurgy in Great Britain

*(From Our Special Correspondent.)*

### The Institute of Metals

The meeting of the Institute of Metals announced to be held at Portsmouth on the 10th and 11th of September did not take place on account of the war. But the papers which would have been read and discussed were formally presented at a meeting in London on the 10th and discussion was invited by correspondence in the Journal of the Institute.

### The Influence of Coke on Corrosion

In their second report to the corrosion committee of the Institute of Metals, Dr. G. H. Bengough and Mr. Jones gave out, as the result of their researches, that coke exerted no deleterious action when in contact with immersed Admiralty brass, and generally had rather a beneficial effect.

Mr. Arnold Philip, in a convincing paper, flatly contradicted the statements so made, which he regarded as an entirely erroneous departure from the generally accepted views on the theory of corrosion. The report in question stated, in effect, that coke in close contact with condenser tubes of Admiralty brass, whether in stagnant or running sea-water at ordinary temperatures, had no material influence on the amount of corrosion, either local or general, and did not cause dezincitification, buti n general had a slight retarding effect on the speed of corrosion.

The author asserted most positively that coke in contact with condenser tubes in sea-water caused an acceleration of corrosion which was a very real and important source of trouble, and this was a fact which had been known for many years to all engineers who had to deal with corrosion, particularly in connection with condenser tubes, and had long ago attained the status of a truism. He had made many dozens of experiments with pieces of Admiralty brass condenser tubes to which fragments of coke were tied with cotton, and immersion in either stagnant or running ordinary sea-water at temperatures varying from atmospheric up to 50 deg. C., proved that in every case an acceleration of corrosion was caused by the coke, while an appearance of dezincification was produced in two days at ordinary temperatures.

### Depositing Metallic Coatings by Spraying

A paper by Mr. R. K. Morcom described an effective method of uniformly depositing metallic coatings by spraying heated metal by means of high-pressure air or gases. The apparatus is the subject of British patent No. 2801 of 1912, and consists essentially of two concentric nozzles with a central carrier for a wire of the metal to be deposited.

The inner, or melting, jet focusses a flame of oxy-hydogen or other gaseous fuel on the wire at a short distance from the nozzle, while the outer or spraying jet delivers air or other suitable gas at a pressure of 80 lb. per square inch, which carries away a stream of minute particles of the heated metal and deposits them on the object to be coated and also serves to keep the nozzles and object cool.

It is stated that the hand can be held in the jet without inconvenience and be coated with metal. The consumption of air is from 45 to 50 cu. ft. per minute, and the most economical rate of supply of gases for the melting jet is about 1.5 cu. ft. of hydrogen and 0.5 cu. ft. of oxygen, or about 0.8 cu. ft. of coal gas with 0.65 cu. ft. of oxygen per minute.

The manipulation of the apparatus can be varied to produce either porous or non-porous coatings, and, with certain metals, any deposit from pure metal to pure oxide. Fusible non-metallic substances can also be sprayed, and alloy deposits may be obtained from stranded wires.

### The War and Engineering Trades

An order of considerable magnitude for the machinery and steel work for the construction of dock gates, caisson and swing bridges at the new extension of the Royal Albert Docks was, before war was in sight, placed in Germany by the Port of London Authority. The carrying out of the contract in that country being now out of question, it has now been given to Sir Wm. Arrol & Company, of Glasgow.

The trade of Sheffield has already undergone marked improvement, and continued expansion is practically certain to follow. The bayonet works are naturally very active; a valuable order for shoes and dies for Freemantle, which would in the ordinary course have gone to Germany, has been received, and fairly heavy contracts for steel work for Japan represent new business.

At Birmingham the small arms and ammunition factories are working day and night; good orders for locomotives and rolling stock have been transferred from German firms to British engineers, and a considerable share of the work has come to the district, while orders from the War Office for light constructional steel work, corrugated sheets, barbed wire, tubes and pumps are keeping many works very busy.

In the Tyne district firms doing Admiralty work are keeping their shops going continuously—day and night and Sundays—to cope with the demands for war material, and there is considerable difficulty in obtaining an adequate amount of skilled labor.

### Market Prices

*September*, 1914

Prices not official

| | £. | s. | d. | | £ | s | d |
|---|---|---|---|---|---|---|---|
| Aluminium ingots, ton lots | | | | | 83 | 0 | 0 |
| Alum lump, loose, per ton | 5 | 5 | 0 | to | 5 | 10 | 0 |
| Antimony, black sulphide powder, ton | | | | | 25 | 0 | 0 |
| Borax, British ref. crystal, cwt | | 18 | 6 | to | | 19 | 6 |
| Copper sulphate, ton | 17 | 10 | 0 | to | 18 | 10 | 0 |
| Copper ore, 10% to 25% unit | | | | | | | |
| Caustic soda, 70%, cwt | | 9 | 9 | to | | 10 | 3 |
| Ebonite rod, lb. | | | | | | 3 | 6 |
| Hydrochloric acid, cwt | | | | | | | |
| India rubber, Para, fine, lb | | | | | | 2 | 10 |
| Mica in original cases, medium | | 3 | 0 | to | | 5 | 0 |
| Petroleum, Russian spot, gal | | | | | | | 9¼ |
| Quicksilver, Spanish, bottle | | | | | 7 | 17 | 0 |
| Sal ammoniac, cwt. | | 40 | 0 | to | 2 | 2 | 0 |
| Sulphate of ammonia, ton | | | | | 10 | -- | 0 |
| Sulphur, recovered, ton | | | | | | | |
| Shellac, cwt. | | | | | 3 | 2 | 6 |
| Platinum, oz., nominal | | | | | 9 | 5 | 0 |
| Tin ore, 70%, ton | | | | | | | |
| Zinc sheets, scarce | 42 | 10 | 0 | to | 45 | 0 | 0 |

The Metal Exchange remains closed.

*Tin.*—General depression was somewhat relieved towards the middle of the month by Continental demand through absence of German supplies, Standard being quoted about mid-month at £134 to £136 on minimum quantities.

*Copper.*—In copper the exchange remained closed. At the beginning of the month, owing to restricted selling consequent on this, copper changed hands as low as £52. Best selected was officially fixed at £57.10.0 to £58.10.0 (11th).

*Scotch Pig.*—Market very quiet. Settlement price 57/—.

*Haematite.*—Settlement 66/—.

*Cleveland.*—At mid-month 52/11, but has since declined considerably, being quoted later at 50/11½.

*Lead.*—The market is quiet. English lead is fairly steady at £19.15.0 to £20.0.0.

## Recent Chemical and Metallurgical Patents

### Fixation of Atmospheric Nitrogen

**A New Nitride Process.**—Among the various processes for the fixation of atmospheric nitrogen one particular class which has attracted considerable attention in recent years is characterized by, first, the production of a metallic nitride by reaction of the metal with atmospheric nitrogen; second, by production of ammonia from the nitride, and third, the regeneration of the metal, so that with respect to the metal the process is cyclic. Perhaps the first suggestion in this line was to use lithium (this journal, April, 1906, p. 122). The lithium nitride, formed by the reaction $3 Li + N = Li_3N$, is treated with water, yielding ammonia and lithium hydroxide, and the latter is electrolyzed for the regeneration of metallic lithium. This was considered too complicated and expensive. One special process which has furthest advanced on this principle is the Serpek process in which aluminum nitride is produced from bauxite and nitrogen, followed by decomposition of the nitride by water or caustic soda solution, thereby liberating the nitrogen as ammonia and producing alkaline aluminate solution from which pure alumina can be obtained (this journal, Vol. X., p. 745, Vol. XI., pp. 137, 139, 281).

Two patents just granted to Prof. JOHN E. BUCHER of Brown University, Providence, R. I., describe a new process which in its general principle belongs to the class above described. Its distinctive feature is that the nitride is not decomposed by water or caustic soda solution, as above, but by a mineral acid, or by some other hydrogen compound such as the acid salts, ammonium salts, etc. In the patents examples are given for the following acids, acid salts, etc.: $HCl$, $NaHCO_3$, $NH_4CL$, $NH_4Br$, $NH_4I$, etc. The advantage claimed by the inventor over the use of water or caustic soda solution for treatment of the nitride is stated as follows: "A characteristic property of nitrides of the metals and metalloids—lithium, magnesium, calcium, barium, strontium, aluminum, silicon, etc., and of boron nitrid —is their power to decompose water at the ordinary, or at more or less elevated temperatures, as the case may be, to form gaseous ammonia, and a hydroxide or oxide of the metal or metalloid. This method of producing ammonia is not economical because the oxide or hydroxide remaining has little value as such, and must be reduced to the metallic state before it can absorb nitrogen to reform the nitrid, and it is very much more difficult and expensive to reduce the oxides and hydroxides of the nitride forming metals than to reduce the haloids of said metals.

The principle of the Bucher process is shown in the most simple way in the following example:

$$3\,Ca + 2\,N \text{ (from air)} = Ca_3N_2.$$
$$Ca_3N_2 + 6\,HCl = 2\,NH_3 + 3\,CaCl_2.$$

"Electrolysis of the so produced chloride of calcium gives chlorine and calcium, and the former may be utilized as such, or may be used to form hydrochloric acid, while the calcium may be converted into calcium nitride to be reacted upon by hydrochloric acid. My process is hence adapted to any industry wherein hydrochloric acid is available or wherein it may be produced."

As adapted to the ammonia-soda industry, the process is described as follows: "Many attempts have been made to utilize the chlorine of common salt, used in the ammonia-soda process, for producing bi-carbonate and carbonate of soda. Solvay and Mond made many experiments with this end in view, but up to the present time none have proven economically successful. The common practice of to-day allows all of the undecomposed common salt, which amounts to about 30 per cent of the total quantity used, and much of the chlorine of the decomposed salt to go to waste, some of the chlorine combined with calcium being recovered and utilized as calcium chlorine. My invention renders possible the saving and utilization of all of the undecomposed common salt, and substantially all of the chlorine of the salt which becomes decomposed, while furthermore resulting in an increase of approximately one-third of the quantity of ammonia present in the cycle.

"The manner of conducting my process in connection with the ammonia-soda industry is as follows: The mother liquor from the crude bi-carbonate of soda produced in the carbonating tower is evaporated to dryness in any suitable evaporator; and the free or volatile ammonia is collected by brine in the usual manner; a residue consisting essentially of a mixture of dry ammonium chloride and sodium chloride being obtained. This mixture is then heated to the subliming point of ammonium chloride, to wit, about 300° C., and the ammonium chloride is condensed to a solid sublimate leaving the sodium chloride behind in an especially pure condition, suitable for any use, such as table salt, or for strengthening the brine used in the ammonia-soda process; while all of the ammonia corresponding to the decomposed sodium chloride is thus recovered in the form of dry ammonium chloride. The ammonium chloride is then brought into contact with a nitride at the proper temperature, usually a dull red heat. Many nitrides are capable of reacting with ammonium chloride, in practically all cases with evolution of heat, producing ammonia or ammonium chloride and a chloride of the metallic base of the nitride. For example, calcium nitride reacts, in this connection, as follows: $Ca_3N_2 + 6\,NH_4Cl = 8\,NH_3 + 3\,CaCl_2$.

"The reaction in this case evolves sufficient heat to maintain itself after it has once been started, and if moisture be excluded, which is preferable, the reaction takes place quantitatively and anhydrous ammonia and anhydrous calcium chloride are produced. The ammonia needs only to be cooled and compressed, either by the pressure produced in the generator, or by mechanical compression, to immediately liquefy it. The calcium chloride hereby produced is well suited to serve as an electrolyte in an electric furnace, and is preferably so used in the electrolytic step of the process leading to the re-formation of calcium nitride." Various reactions are also mentioned in which magnesium is the metal in the cyclic process instead of calcium.

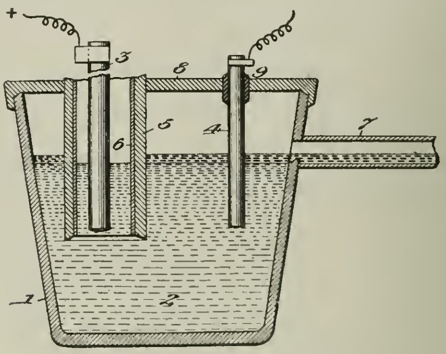


FIG. 1—ELECTROLYTIC FURNACE

The electrolytic process is carried out as follows: In Fig. 1, the iron pot 1 contains the fused salt 2, while 3 is the anode and 4 the cathode. Chlorine is set free at 3, collects within the tube 5 and is carried off. The metal (calcium, magnesium, sodium, etc) is set free at 4 and carried off through tube 7 and is then "introduced into the reaction tube 10, Fig. 2, which latter may be heated in any suitable manner, as by a number of Bunsen burners 11. The sodium 12, for example, in the retort or reaction tube is converted to a nitride by passing nitrogen or a suitable nitrogenous reagent, e.g., free nitrogen, through the tube, such reagent passing thereinto from a tube or pipe 13, and the unused portion of the same escaping via tube 14. Cocks or valves 15 may be provided in these last-mentioned pipes. The halogen, e.g., chlorine, escaping from pipe 5, is collected and may be combined with hydrogen, for example, to form hydrochloric acid; and when the nitride of magnesium, for instance, in tube 10, is reacted upon with said acid, which may be introduced into said tube in any suitable manner, as by injection * * * ammonia formed may escape through tube 14, while the resulting reformed haloid salt will remain in the reaction tube, from which it may be afterward removed preparatory to again electrolyzing the same." (Patents 1,113,598 and 1,113,599, October 13, 1914.)

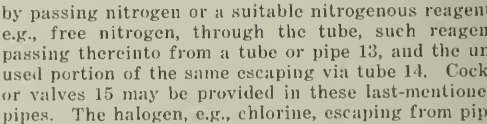


FIG. 2—REACTION TUBE FOR PRODUCTION OF NITRIDE

**Absorption of Nitrous Vapors in the Dry and with Heat by the Aid of Lime.**—A patent of Alphonse Theophile Schloesing, Paris, France, applies to a process by which a better heat-regeneration is obtained in the fixation of atmospheric nitrogen. Air is dried with sulphuric acid before entering the electric heating furnace (in which discharges are passed through the air) and leaving the same the air contains nitrous vapor. It then passes into a heat-exchanger, where part of its sensible heat is given off to the gases escaping from the absorber, freed from nitrous vapor. These re-heated gases can now be used to dry and dehydrate the lime used for the absorption of those nitrous gases in the absorber. The gases which gave off part of their heat are still further cooled down to about 300 or 400 deg. C. and enter now the absorber, where their nitrous content is retained. Leaving this absorber still hot enough, part of it may be used to concentrate the sulphuric acid for air-drying, whereas the other part is re-heated in the heat-exchanger as set forth above. No external heating is required throughout this process. (1,092,295, April 7, 1914.)

### Metallurgical Furnaces.

**Melting Furnace.**—A combined reverberatory and stack furnace is described by GRENVILLE MELLEN, of East Orange, N. J. The flame passes over an inclined hearth and through an arch into the shaft, where it preheats the charge. The molten metal accumulates in a sump, where it is separated from any lumps by a refractory shield. The product can be further treated in a refining chamber, which is protected from radiation by a cover. Finally it flows into a pot in front of the furnace. (1,092,938, April 14, 1914.)

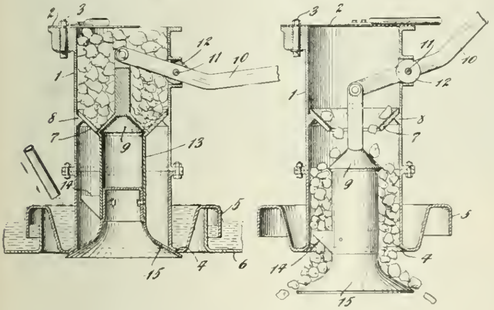


FIG. 3—HOPPER FOR GAS PRODUCER

**Hopper for Gas-Producers.**—To evenly distribute fuel in a producer, WM. A. JONES, of West New Brighton, Staten Island, N. Y., has devised the hopper shown in the two diagrams of Fig. 3. It consists of an upper loose ring 7, closed by the valve 9 extending cylindrically below and ending in a flared spreader-plate, fitting tightly to a seat 4, on account of the looseness of ring 7. Three guides for the bell are also provided. The distance with which the coal will fall from the producer-center will depend upon the height of its fall, the angularity of the spreader plate and finally also on the height above the coal surface. (1,090,857, March 24, 1914.)

**Reversing Valve.**—A reversing valve, in which the use of cooling water is almost avoided and the walls are brick-lined and cooled by air is patented by JEROME R. GEORGE, of Worcester, Mass. The valve itself is divided into sections, one of which is closed by a cover being lined and connecting two gas flues of the heating furnace. The open segmental section is for admission and regulation of air, its two connecting walls between the circular wall-ends and the skew-back, being curved. Air pockets are provided between lining and shell, to cool the former. Only skew-back and pan receive cooling water. (1,093,047, April 14, 1914.)

### Electric Furnaces.

**Electric Melting Furnace for Medium Temperatures.**—ERNESTO STASSANO, of Turin, Italy, and NAPOLEON PETINOT, of Niagara Falls, N. Y., have obtained a patent on an electric melting furnace for copper, alloys, etc., the furnace being of the radiation type. The furnace has already been described in our October issue, page 645. The main features are the eccentricity of the furnace shell and melting chamber, the axis of the latter being above the other. On account of this thicker refractory filling the bath is well protected against heat losses, whereas the highly heated but thinner roof allows a better cooling. A charging device, consisting of a turning-disk with a funnel, a hopper closed on top, permit charging without admitting air to the furnace. The electrodes are inclosed in a cylinder and held by a hollow water-cooled rod, sliding on guides and moved by means of hydraulic pressure. (1,093,494, April 14, 1914.)

**Calcination of Granular Carbon and Production of Graphite.**—A continuous electric furnace for the production of granular graphite is patented by JOHN W. BROWN, of Lakewood, O. (National Carbon Company). The vertical and polygonal type contains an outer and an inner cylindrical wall, with a cover on top, through which the upper carbon electrode reaches into the furnace. The three lower horizontal electrodes pass through sleeves in the inner and outer walls and cannot with a cylindrical carbon channel, at the bottom of which a conveyor removes the granulated product. The charge, fed into the hopper, is carried upwards by a hoist between the two cylindrical walls and absorbs thereby heat from the hot product inside. The charge is tilted on top, passes the intense hot zone and falls into the carbon channel where it gives heat off to the fresh charge. A vertical modification and two horizintal designs are further described. (1,093,382, April 14, 1914.)

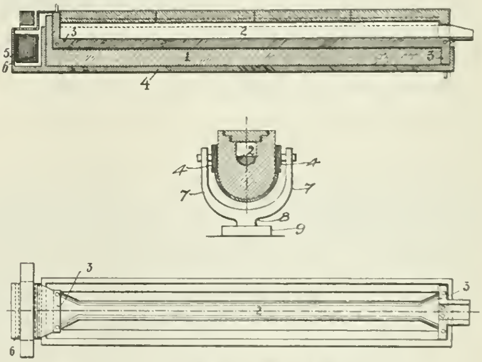


FIG. 4—INDUCTION FURNACE

**Electric Induction Furnace.**—ALOIS HELFENSTEIN, Vienna, Austria, uses the casing of a long-shaped furnace as conductor for the secondary current to the bath. This casing surrounds the furnace concentrically effecting thereby a natural cooling. Fig. 4 shows a vertical longitudinal section, a vertical cross-section, and a plan of the furnace. 1 indicates an extended furnace tube in which the metal 2 to be heated by the current is contained. At the ends of the tube water-cooled poles 3 are arranged, which transmit the induced secondary current on the one hand from the secondary winding 6, and on the other hand through the furnace-casing 4 to the metal bath 2. The primary winding of the transformer is shown at 5. (1,093,328, April 14, 1914.)

**Moving-Electrode Furnace.**—Instead of fixed electrodes, HENRY H. BUCKMAN, Indianapolis, Ind., uses rotating eletcrodes to obtain a better and quicker distribution of heat in an electric furnace. Three electrodes are being carried by a support, fastened to a vertical rotating member. These arms and the member are water-cooled and the electrodes isolated from the support, one conductor leading direct to the middle electrode, while the other divides and supplies the two outer ones. All three electrodes rotate eccentrically with different distances from the center to cover as much surface as possible of the bath, the current passing through and from the middle to the two outer electrodes. The distance of these outer electrodes from the center electrode is kept equal. (1,092,764, April 7, 1914.)

**Electrode Construction.**—According to a patent of JOHN W. BROWN, of the National Carbon Company, electrodes can be built up of segments and keyed together by means of ribs and complimentary grooves, both being shunted to insure a wedging action of all the parts. The electrodes are best started with varying lengths, the ends of each being leveled to force them into better contact. The center may be made hollow. (1,091,559, March 31, 1914.)

### Iron and Steel

**Refining Pig Iron.**—Pig iron can be improved so as to be equal to cold blast-iron, according to a patent of VICTOR STOBIE, Sheffield, England. The liquid metal from the blast-furnace is treated in an electric-furnace under a refining-slag of about 60 per cent lime and 40 per cent silica and kept free from iron oxide by additional carbon or deoxidizer. The bath is stirred up by throwing limestone into it, the carbonic acid causing violent evolution. After this the bath is allowed to rest. Too much limestone would reduce silicon, manganese and phosphorus. (1,093,892, April 21, 1914.)

**Direct Production of Iron and Steel in a High-Pressure Furnace.**—CARL OTTO, Dresden, Germany, describes a somewhat complicated method of producing iron or steel in a furnace under pressure. Spongy iron is first produced by carbon monoxide in a clay vessel heated from the outside by producer-gas. At the bottom is a charge of pure iron or steel, on top of it is charcoal mixed with ore, and on top of this a fuel chamber is provided, containing inferior fuel with an electric resistance imbedded herein. The vessel with the charge is heated and the $CO_2$ from the reduction zone passes up and into the electrically heated fuel chamber. The CO so produced is used partly for burning and the other part takes the place of the $CO_2$ in the ore-chamber for further reduction. Gas-circulation is produced by a blower. A second electric resistance is provided at the base of the vessel to form and maintain a sump of mother metal, which bath under pressure also absorbs CO, so removing all remaining protoxides. (1,089,951, March 10, 1914.)

**Use of Peat in Production of Sponge-Iron.**—Objections to the use of peat as fuel in iron reduction reside in its tendency to disintegrate in the shaft furnace and its inability to sustain the burden of the charge. It is proposed, however, by PER ANDERSON, of Arvika, and ERIK EDSON ODELSTIERNA, of Stocksund, Sweden, to make use of this fuel in a metallizing or sponge-iron process, by thoroughly mixing the powdered peat with iron ore, charging the mixture in a receptacle and heating the latter externally by combustion of gas. The reduction thus takes place while the ore and metal are still in a solid state. (1,105,870, Aug. 4, 1914.)

### Gold and Silver

**Treatment of Anode Residue.**—Anode residues from the electrolysis of copper bullion contain gold, silver and some copper. The recovery of the copper and the preparation of the precious metals for subsequent refining and separation, are objects of a process patented by Dr. EDWARD KELLER, of Perth Amboy, N. J. The anode residues are first filter-pressed and then treated with concentrated commercial sulphuric acid in just sufficient quantity to dissolve the copper present or render it soluble. After this treatment the copper can be dissolved in hot water, and the decopperized precious-metal residue refined for the formation of Doré bars. For residues from crude converter copper, the following mixture is made: 2000 lb. residue (41.2 per cent copper) and 2760 lb. sulphuric acid at 66° Baume, or 67 lb. of acid per unit (20 lb.) of copper. For residues from refined copper: 2000 lb. residue (15.1 per cent copper) and 460 lb. acid at 66° Baume, or 30.7 lb. acid per unit of copper. The mixture is heated at a temperature of about 450° F. and subsequently dissolved in hot water, whereby from 95 to 99 per cent of the copper is recovered in a neutral solution suitable for return to the electrolytic tanks. (1,110,493, Sept. 15, 1914.)

### Copper and Zinc

**Improvement in Bessemerizing Copper Matte.**—In the usual method of recovering copper from matte the latter is blown in a converter with the addition of silicious flux, with the result that there is first formed a slag of silica and iron which is skimmed, after which the blow continues to reduce white metal, or sulphide of copper, to the metal. The copper is subsequently treated in a reverberatory furnace, where a slag containing copper silicate is formed. An improvement in this procedure is claimed by Mr. JAMES B. HERRESHOFF, JR., of New York City, in a patent which he has assigned to the Nichols Copper Co. The invention contemplates the utilization of heat formerly wasted, and the more efficient retreatment of the reverberatory slag.

Using two basic converters, silicious material and matte are blown in the first one until a clean fusible slag is made containing part of the iron in the matte. This slag is removed and silicious material added in excess of the requirements of the remaining iron. The blow is continued until all the iron has been slagged and white metal produced. The slag and excess silica are now a viscous mass, from beneath which the white metal is poured and transferred to the second converter and blown to blister copper. A new charge of matte is then added to the viscous slag in the first converter and the process repeated. By this method the silicious material is heated by the bath or charge, and when brought into contact with the next charge of matte tends to raise its temperature instead of cooling it. Another advantage claimed is that cleaner slags are produced, because at no time is slag poured from a bath of copper. The reverberatory slag mentioned above can be used to advantage as silicious flux in the converting operation. (1,103,925, July 14.)

### Alloys

**An alloy of tungsten and nickel,** having the property of ductility, and from which the nickel can be completely removed without resort to fusion, is patented by Mr. HANS KREUSLER, of Wilmersdorf, near Berlin, Germany. The alloy and the method of making it are specially applicable to the production of metallic tungsten filaments for incandescent electric lamps. Alloys of 90 per cent tungsten and 10 per cent nickel prove to be of special utility. The nickel can be driven from finely drawn wires of such an alloy by subjecting them to heat in a highly rarefied atmosphere or in a vacuum, as by passing an electric current through them. The resulting tungsten wires can be used as lamp filaments. (1,110,303, Sept. 8.)

# The Electric Crane in the Electrolytic Copper Refinery

In several branches of the metallurgical industry the electric traveling crane has virtually become a part of the process and performs various functions aside from the transportation of materials. It would be difficult to conceive of an open-hearth steel works without the several distinctive types of electric cranes that have been developed along with the mill practice, and somewhat analogous conditions prevail in modern plate glass works and particularly in the "casting-hall" where large crucibles of molten glass are withdrawn from the furnaces and poured by electric traveling cranes of special construction.

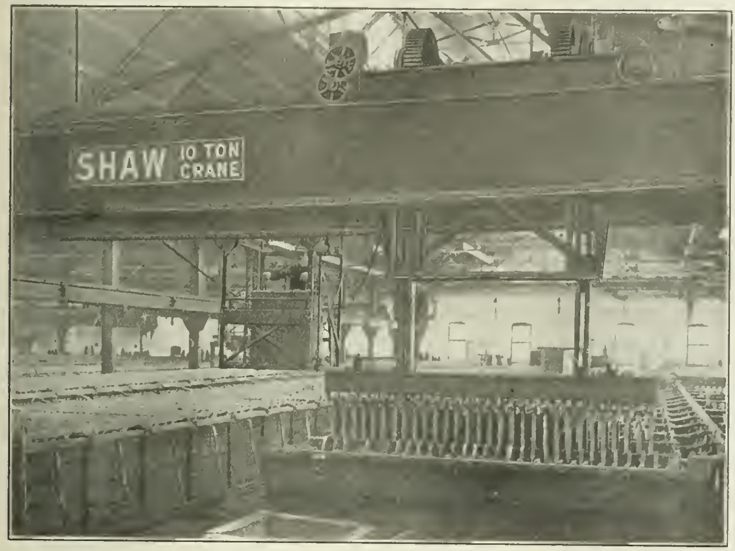


FIG. 1—PLACING THE ANODES IN THE ELECTROLYTIC TANK

The crane shown in the accompanying illustrations is employed for the single purpose of handling the electrodes of electrolytic copper refining tanks. The lifting frame comprises two parallel I-beams from each of which depends a series of hooks which engage the supporting lugs on the electrodes. With the lifting frame lowered into position, a slight movement of the trolley or carriage along the bridge serves to engage the hooks and the entire anode or cathode content of the tank is then lifted in the one operation.

The distinctive feature of this crane is the rigid-bar hoist, the two vertical bars supporting the lifting frame and traveling in heavily braced guides as shown in the illustration. The principal advantage lies in the fact that the lifting frame cannot possibly tilt and drop the electrodes, even if the load is unbalanced, while at the same time all tendency of the load to sway due to the travel motions is effectively resisted.

This crane has three independent motors for respectively the hoist, the cross travel of the trolley and the longitudinal travel of the entire crane along the runway. The operator's cage is supported from one of the bridge girders and at the center of the span, and the speed and accuracy attained by an experienced operator are little short of amazing.

Prior to delivery in the tank house each group of thirty anode castings is assembled in racks on a transfer car, the anodes being correctly spaced with reference to the position of the hooks on the lifting frame.

Fig. 1 shows the operation of the crane while placing the anodes in the electrolytic tank.

Fig. 2 shows the crane with a lot of refined copper cathodes immediately after removal from the electrolytic tank.

The illustrations are from photographs made at the works of the United States Metals Refining Company at Chrome, N. J.

The cranes were built by the Shaw Electric Crane Company, one of the subsidiaries of Manning, Maxwell & Moore, Inc.

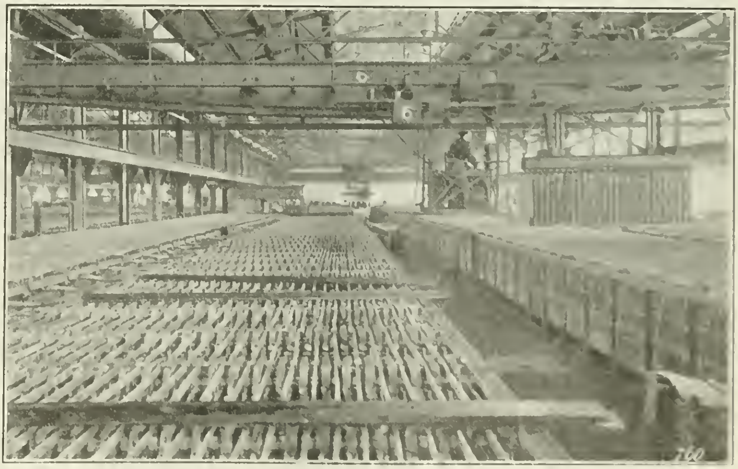


FIG. 2—CRANE WITH CATHODES AFTER REMOVAL FROM ELECTROLYTIC TANK

---

**The reported discovery of platinum** in the Boss mine in the Goodsprings, or Yellow Pine, mining district in Nevada, seems to be confirmed by the published assays of a reputable eastern firm. Palladium and gold also are said to occur with the platinum, giving an ore of unusual value.

## Calorizing

### Coating Metals with a Layer of Aluminium Alloy for Protection Against High Temperatures

H. B. C. Allison and L. A. Hawkins, of the Research Laboratory of the General Electric Company, Schenectady, N. Y., have published an interesting article on "Calorizing" in the October issue of the *General Electric Review*, from which the following notes are taken.

Mr. T. Van Aller discovered a process of heating metals in revolving drums with mixtures containing, among other things, finely ground aluminium, by which a surface alloy containing aluminium is produced (From this it would seem that the process, in its principle is similar to sherardizing. See our Vol. V, page 187, and VI, page 191.) In the case of copper, this alloy is of the nature of an aluminium bronze, but richer in aluminium than the ordinary alloy of that name and more resistant to heat, so that copper thus treated is protected up to the melting period of the alloy from the scaling which occurs when untreated copper is heated above 300 deg. C. The same general result was obtained in the case of iron and steel. Some use was made of this process, which was called "calorizing," for treating copper soldering irons and iron resistance wires for heating devices.

Modifications of the process, extending it to further applications, were made by Mr. E. G. Gilson, of the Schenectady Research Laboratory. Pieces which, because of their shape or size, are not adapted for tumbling, may be calorized by packing them in, or painting them with, a suitable mixture, and heating them. Thus, the size of the heater is the only limitation on the size of the piece that may be calorized. Wire or ribbon may be treated by a continuous process, by passing it through a heated pipe containing the proper calorizing mixture.

There appear to be many places where it is desirable to use iron vessels or apparatus at temperatures above red heat, and at such temperatures, ordinary iron rapidly oxidizes and scales away. After iron is calorized the effect of heating is slight. Instead of burning and the scale falling off, as in the case of untreated iron, practically no effect can be detected after a considerable time—certainly none which injures the surface.

Another application of this process is to iron wire or ribbon such as is used in electrical heating units. An untreated piece of this ribbon will burn out in four or five hours at the most, whereas tests upon calorized pieces have shown that the life is increased at least fifty fold, and in the best instances over one hundred fold. The results of tests made at Pittsfield indicate that a life of over 500 hours may be expected from calorized heating units run at a temperature of 800 deg. C.

Calorized seamless iron tubing is being used for combustion tubes in the research analytical laboratory where pure oxygen is brought in contact with the metal, at temperatures from 900 to 1000 deg. C. These are thus far operated all right and still appear unaltered after nearly 100 hours' use.

The above facts seem to indicate that this is a simple method for extending the use of iron under oxidizing conditions at high temperatures, and for greatly prolonging the life in those instances where it is now used but must be renewed at frequent intervals. In the case of small mufflers or crucibles, where temperatures are below 1000 deg. C., this treatment of cheap cast or wrought-iron shapes seems very promising. While the life of the coating depends on the temperature at which it is used, as well as on the duration of time taken in its preparation, i.e., the quantity of aluminium which alloys with the surface of the iron, it does not permit of long use at temperatures much in excess of 1100 deg. C.

Copper parts also, which are exposed to high temperature, can have their life increased by calorizing. In some cases calorized copper may be used advantageously in place of aluminium bronze. For instance, a large power station had trouble from early corrosion of its condenser tubes. These tubes were aluminium bronze and were supposed to last at least a year. As a matter of fact, while occasionally tubes would last as long as six years, other tubes would fail in four to six weeks after they had been installed. About two and a half years ago a set of calorized copper tubes was installed and so far not a tube has failed.

In some cases the life of copper contacts can be increased by calorizing. For instance, a set of railway controller contacts which were calorized showed double the life of the ordinary untreated contacts.

As has been said, the effect of calorizing is to produce a surface alloy containing aluminium. The thickness of this alloy varies with the length of time during which the piece is subjected to the calorizing process, and the percentage of aluminium varies through the coating, being greatest at the surface. This is shown clearly by a cross-section of a calorized copper rod. The line between the alloy and the unchanged copper is sharp, but the color of the alloy varies from a rich golden-yellow next to the copper to a silvery-white at the surface.

When an iron pipe or ribbon is calorized for a heating unit, a portion of the iron becomes alloyed with the aluminium. Naturally this results in changing both the resistance and the temperature coefficient. The thicker the calorizing coat the greater is the change. This is shown by Table 1, in which No. 1 was given a lighter coat than No. 2.

Table I

| Sample | Ohms per M (19°) | Temp. Co-Ef. Elec. Resis. (O — 150°) × $10^{-3}$ |
|---|---|---|
| Iron ribbon | 0.905 | 5.61 |
| Same calorized, No. 1 | 2.45 | 1.72 |
| Same calorized, No. 2 | 7.6 | 0.151 |

A thin ribbon may easily be calorized all the way through, and then becomes quite brittle.

The dimensions and weight of either a copper or iron piece are slightly increased by calorizing. The increase of dimension is much less than the thickness of the alloy coat, the greater part of which simply takes the place of the original metal. The dimensions may, however, increase several mils and there is a tendency to a greater increases at the edges than on flat surfaces.

For iron, calorizing is intended only for protection at high temperatures. It does not compete with galvanizing, sherardizing, and other similar processes for protection against oxidation or corrosion at low temperatures. Its usefulness lies within a range of temperature much higher than a galvanized or sherardized coat could stand.

For copper, calorizing is effective against corrosion at low temperature as well as against oxidation at high temperature. The upper limit is determined by the melting point of the alloy, which is somewhat lower the heavier the calorizing treatment, since that means an alloy with a higher aluminium content.

The probable explanation of the effect of the aluminium in the surface alloy is that a thin coat of alumina forms which prevents further burning of the metal beneath. It is well known that a pure aluminium wire may be heated in the air to a temperature several hundred degrees above its melting-point, without flowing, when the thin alumina shell which surrounds and supports the molten metal is easily seen.

The orginal article in the *General Electric Review* contains some interesting microphotographs.

# Present Status of the Fink Furnace

BY H. B. PULSIFER

The Fink furnace has now been before the public in various ways for some years. In view of the fact that no large commercial units are operating, while the Fink Smelters Company yet claims to have a valuable addition to metallurgical equipment, this contribution is offered as recording some of the difficulties encountered in trying to improve metallurgical practice and get more value from some ores and some value from ores as yet practically worthless.

### Patents

The Fink furnace is presented by men who are not at present engaged in the smelting industry; that is, they have no works of their own in which the furnace could be placed and put to work as a matter of regular routine. A very large amount of money has been expended on the evolution of the furnace and its operation, so that to secure the investment and legitimate profit every detail possible has been patented. The securing of domestic and foreign patents has consumed much valuable time and delayed matters at several times when otherwise much progress might have been made.

Patents on metallurgical devices are being issued these days and upheld years after they have been applied for; the Fink sponsors have not seen fit to attempt other than the most open and conservative business policy. The matter of foreign patents has more than once caused delay; at this very moment accessory equipment promising increased usefulness to the furnace proper awaits patent issues in countries so disturbed by the war that business and communication are paralyzed. Whether or not obtaining patents be accepted as the best possible course, the Fink company has chosen this course and has experienced this trouble.

### Suitable Raw Material

The ideas of the peculiar field for a furnace of this type have considerably changed since the early days of Mr. Fink's efforts at smelting copper concentrates. It is realized that the type of furnace is hardly adapted to compete with the regular methods employing large units for smelting copper ores. On the other hand, it has become more and more evident that the furnace has a special field in that it can assimilate a mixed sulphide ore and separate it into three parts, two of which are valuable while the third is barren and holds the undesirable constituents of the original ore. It is the method of treatment which produces a volatile, condensible portion containing zinc and lead; a matte or metal containing copper and precious metals, and a slag of customary composition devoid of appreciable value.

With the growth of the idea that the furnace could not compete with larger units on simple ores the aim has been to place furnaces where their success would be pronounced and permanent.

Available ore-deposits and abundant raw material have not lacked from this point of view. The countries of the globe are profusely supplied with ores which are going begging at the present time. Great deposits of metal-bearing materials, the individual metals of which would be worth from $20 to $100 per ton of raw dirt, are idle or awaiting the proper treatment method. Other ores are today sold in great quantities for small fractions of their metallic values because one metal is thrown away to get another, or separation is extravagantly costly.

The Fink company has not been in a position to acquire any of these numerous deposits, exploit the mine, build the plant, smelt the ore and enter the metal-selling field. Such operations demand almost unlimited capital, besides several varieties of managerial resources; the company has appreciated this phase and refrained.

### Sympathetic Hands

With this plethora of raw material available it is not difficult to imagine that numerous companies would be only too glad to take over and use the process; such is the case. Numerous concerns are only awaiting the opportunity to make the effort and reap the benefit. A review of such cases, or the ease with which sufficient capital may be acquired, wonderfully enhances one's already vigorous conception of the greed of man. The Fink company wants to control the furnace sufficiently to insure its future and get a fair proportion of any profits.

Metallurgists are only too well aware of the difficulty in introducing new equipment and getting it treated in proper manner; many a fine invention is thrown down and out by some brute, for some minor defect, through prejudice; the most perfect machine or beautiful process usually requires patient and sympathetic coaxing until its operation is perfect and its intended operators learn that they are to accept it and keep it in shape.

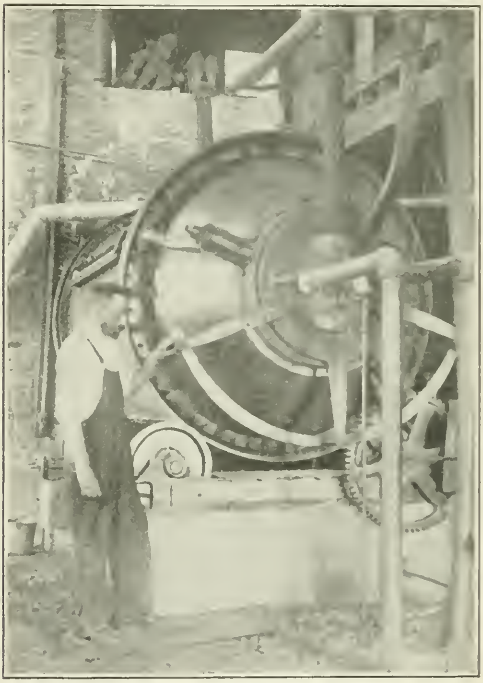


FIG. 1—FINK FURNACE IN OPERATION

On this basis many opportunities have not been considered where it was obvious that merely perfunctory attention could be expected. The Fink company does not intend to place any of its equipment in irresponsible hands.

### Plants Contracted For

About a year ago the Fink company entered into contract with the owners of the Teziutlan Copper Co., mines and plant in Puebla, Mexico, with every promise of seeing several of the Fink furnaces in prompt use under desirable conditions. Shortly after preparations were started the plant was forced to close down by war conditions; from that time the plant has been idle and no work possible.

During April, 1914, contract was made with the Mond Nickel Co., plant at Coniston, Ontario; furnace was shipped and installed and dried out for firing up. Almost on the minute of charging, cables closed the entire plant due to England's entering the war in this last August.

With both of these companies the contracts were desirable, the raw material abundant and competent technical staff on hand to insure a fair trial for commercial success.

Negotiations are at present under way with yet other companies and it is hoped that before long adequate trial of the furnace will be made to demonstrate its usefulness or otherwise. No runs sufficiently long to demonstrate working costs, life of lining or routine recovery have taken place as yet. Numerous trial runs have led the owners to believe that their confidence in the usefulness of the furnace is not misplaced.

### A Recent Trial Run

The experimental furnace is situated at Wauwatosa, Wisconsin; unfortunately no adequate provision is made for collecting the fume. The following quotations from a report made on a run during August indicate the work the furnace can do.

"The Fink furnace is specially designed for the direct smelting of sulphide ores, being a converter-type furnace, using with equal facility either oil (crude or fuel), gas (natural or producer), or soft coal for fuel.

"It has three or more sets of tuyeres as seen in the accompanying drawing. These are spaced so as to leave at least one position of the furnace in which all of the tuyeres will be found above the tap-hole. This is very essential, for in smelting an ore of the mixed type it often becomes necessary to use the furnace for a time as a reverberatory, and this can be accomplished by simply bringing the tuyeres above the charge, shutting off the high-pressure air, and continuing the oil in order to heat the furnace. The opening and closing of the tuyeres is regulated by means of a cam, and only when any particular set of tuyeres is passing underneath the charge is the full air supply permitted to enter this tuyere box.

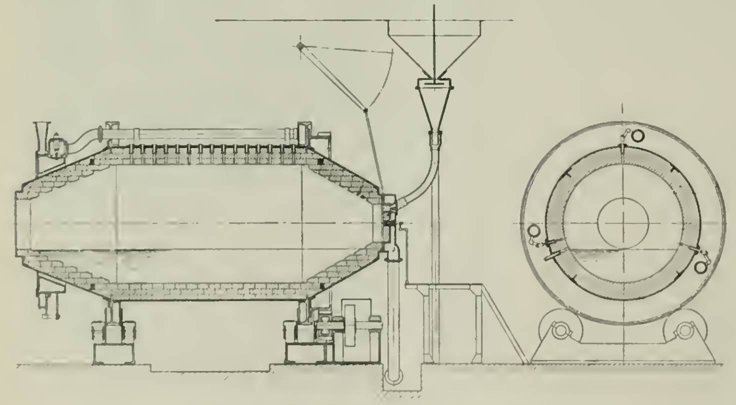


FIG 2—FINK SMELTING FURNACE

"The ore is fed, either continuously or intermittently, through a feed pipe which fits into a stationary door, containing also openings for the introduction of the burner nozzle as well as for the supply of additional air. The waste gases and fumes pass out at the opposite end.

"After the furnace is once brought to a smelting heat, the ore is fed, and rapid desulphurization commences immediately. When the carrying capacity of the furnace has been reached, the reduction is continued until the desired elimination of the zinc and lead have been obtained. The desulphurization of the zinc is not brought about entirely through the action of the tuyeres, as the low-pressure air supplied to the furnace for the combustion of the fuel also plays an important part in the oxidation. Whenever the tuyeres pass underneath the charge a fine spray of molten ore and matte is thrown up against the walls of the furnace. This spray, when it meets the stream of low-pressure air supplied from the end of the furnace, is in an ideal physical condition for rapid oxidation.

"The lead is driven off almost as fast as the ore is melted. However, the zinc requires more time for its elimination. As the sulphur continues to grow less in the charge, it is necessary to supply more fuel, as the tuyeres are no longer operating at full efficiency. It is now desirable to supply additional sulphide ore, free from zinc, if possible, to restore the activity of the tuyeres and to bring about the removal of the remaining zinc.

"While the air supplied through the tuyeres is primarily for the purpose of oxidizing the sulphides in the charge, it also materially assists in driving off the lead and zinc. This action is purely physical and wholly apart from the oxidizing effect of the air, and may be compared, in its effect, to the increased volatilization noticed when passing an inert gas over molten metal.

### Analysis of the Ore

"We have used the analysis made by us as the basis of all of our calculations. Where 'Not determined' we have substituted their figures.

All calculations are based on the short ton of 2000 lb.

### Method of Treatment

"The method of treatment proposed for handling this ore contemplates its smelting in the Fink furnace for the purpose of eliminating, by volatilization, the lead and zinc together with a portion of the silver contained, and the recovery in the matte of the copper, cobalt and gold together with the remaining silver.

The volatilized metals, which are largely in the form of sulphates and oxides, are collected for separation and further treatment.

### Furnace Performance

"In all, 9000 lb. of the ore in question was received. Of this amount 8000 lb. was taken for treatment.

"The material for trial analyzed as follows:

| | *Analysis by Owners* | *Analysis by Fink Smelters Co.* |
|---|---|---|
| Lead | 22.54% | 22.38% |
| Arsenic | .08 | Not determined |
| Copper | .20 | Trace |
| Zinc | 33.29 | 33.48 |
| Iron | 3.77 | 4.60 |
| Alumina | 3.36 | 3.48 |
| Silica | 9.83 | 9.46 |
| Sulphur | 24.74 | 25.10 |
| Cobalt | .87 | .78 |
| Magnesia | .25 | Not determined |
| Lime | .17 | Not determined |
| Silver (long ton) | 18.7 oz. | (short ton) 16.7 oz. |
| Gold | Trace | Not determined |

"The run was made on Thursday, Aug. 27, 1914, beginning at 8 o'clock a. m. with a cold furnace. The run ended at 9:20 in the evening with the tapping of the slag.

"Crude oil, pre-heated, at a pressure of about 60 lb., was supplied through a spray nozzle. The air pressure as supplied through the tuyeres varied from 5 to 7 lb. and the blower delivered approximately 600 cu. ft. per minute.

"At 11:30 a. m. the furnace was at a red heat and 500 lb. of ore was charged. At noon 500 lb. was added, and 1000 lb. between 12:15 and 12:45. At 1:20 a ton was fed into the furnace; another ton was added at 2:15 and the fourth and last ton at 3:10.

"At 6 p. m. 50 lb. of coal was added and at 6:30, 100 lb. more; the furnace heat increased and zinc elimination was strong. At 8:40 35 lb. of coal was added and blowing continued until at 9:20 the slag was tapped and the run ended.

"The total amount of oil consumed during the run was 132 gal., equivalent to 33 gal. per ton of ore smelted. When it is considered that the proper smelting temperature was not attained until toward the end of the operation it is obvious that most of the oil was used in heating the furnace and not in smelting the ore. Much less would be required per ton in continuous smelting.

### Recoveries

"The slag amounted to 1780 lbs.; it analyzed:

| | |
|---|---|
| Zinc | 14.5% |
| Lead | 0.5 |
| Silver | 16. oz. |

Some of the fume analyzed:

| | |
|---|---|
| Zinc | 24.5% |
| Lead | 34.6 |
| Silver | 15. oz. |

"The original ore contained 33.48 per cent zinc, or a total of 2678.4 lb. in the ore charged; and the slag contained only 14.5 per cent zinc, or 258 lb.; hence 2420 lb. of zinc was eliminated during the run, which is equivalent to a trifle over 90 per cent of the total.

"The original ore also showed 22.38 per cent lead, or a total of 1790.4 lb. in the ore charged, and the slag contained 0.5 per cent lead, or 8.9 lb. The elimination of the lead was almost perfect.

"That portion of the slag carrying the matte was separately assayed for silver and showed 18 oz. per ton. Since the original ore carries 16.7 oz. silver per ton, or a total of 66.8 oz. for the four tons treated, and the 1780 lb. of slag carried about 16 oz. of silver per ton, it is evident that about 78.6 per cent of the silver had been volatilized with the lead and zinc.

"Owing to the lack of iron in the ore, the addition of sulphides is doubly necessary to form a slag sufficiently liquid to allow of its thorough separation from the matte. At the time of making this test sulphide ore was not available, and this forms the only unsatisfactory feature of the run.

"In case it is not possible to obtain pyrite ore or concentrate to add to the furnace before tapping the charge, it will be necessary to add limestone at the commencement of the operation, so as to assure the production of a more liquid slag, whereby a better separation of the matte and silver will be obtained.

### Collection of Fume

"Substantially all of the volatilized zinc, lead, and silver which are eliminated from the furnace in the smelting operation are positively collectable as fume or concentrate in the standard form of bag-house now widely used for that purpose.

"The cost ot the regular blast-furnace plants for recovering the zinc, lead and silver products in the bag-house, where a *minimum* of fume is produced, cannot be applied to our particular case where the reverse is true, for we produce a *maximum* of fume and recover a correspondingly greater amount of product; hence our cost for this recovery per ton of product is much less.

"It is safe to say that $1 is a high estimate of the cost of recovering a ton of fume produced from the Fink furnace, which would represent for this mixed type of ore about 70 cents per ton of charge treated. In a large installation this cost could undoubtedly be materially reduced.

"The bag-house product in the case of this ore would be an impure zinc oxide, mixed with lead sulphate, and carrying that part of the silver that has not been taken up by the matte in the furnace, or contained in the slag, and would be of a somewhat different composition to that of the product secured in this particular run, inasmuch as the zinc and silver being lighter when passed directly through the stack did not condense as rapidly as the heavier lead sulphate.

### Costs

"As to the costs of the smelting operation, it may be stated in general that this is largely governed by local conditions. If oil may be had for 3 cents per gallon, the fuel item for smelting purposes alone would not exceed 60 cents per ton of charge.

"The attendance is about the same as that required for handling the ordinary basic converter, and three men on a shift would be more than ample to serve a 100-ton furnace. As the ore-feed is automatic, the sole labor, aside from the preliminary handling of the ore, consists in tapping the furnace, oiling the machinery, and collecting the recovered products.

"The following, by way of a summary, is an approximate estimate (exclusive of interest, depreciation and overhead) of the cost per ton of smelting the mixed ore in the Fink furnace, based on a daily capacity of 100 tons, beginning with the crushing of the ore to 2-in. size, and ending with the elimination of the volatile products from the furnace, and the recovery of the copper-cobalt matte carrying the gold and that portion of the silver not taken over with the fume or carried in the slag:

| | Cost per Ton |
|---|---|
| Crushing | $0.05 |
| Electric power, including machine shop, lighting, etc., at $40 per hp per year | .55 |
| Labor—3 shifts of 1 furnace tender at $3.50 and 1 laborer at $2.50; 2 shifts, 1 engineer at $3.50; total $25 per 24 hours | .25 |
| Superintendent at $3,600 and clerk hire at $1,200, $4,800 per year | .13 |
| Oil, 20 gallons at 3 cts | .60 |
| Total | $1.58 |

Whether we agree with the Fink company in regard to its costs, or not, and whatever view we may take of the ease or difficulty of turning the fume into commercial products, we have to admit that in this case a raw ore of the most refractory nature has been broken up and put a long way on its course to complete usefulness without any flux. This particular ore has a homogeneous steel-gray appearance and is absolutely beyond physical separation. It is undesired by either lead or zinc smelter and has almost no commercial value. Should the actual operating costs come anywhere near the estimates, the furnace is of remarkable promise.

Chicago, Ill.

---

The new concentrating mill of the Daly West Mining Co., at Park City, Utah, was expected to be ready for operation about October 15.

The Werner & Pfleiderer Company, the well-known makers of machinery for the chemical industry, are increasing their manufacturing facilities by the addition of an up-to-date extension to their foundry at their factory in Saginaw, Mich.

## Gas-Blowing Engines

The Mesta Machine Company of Pittsburgh, Pa., are now building for the Pennsylvania Steel Company of Steelton, Pa., two gas-blowing engines of 46-in. and 84-in. cylinder diameters and 60-in. stroke. These engines are believed to be the largest gas-blowing engines ever built in the United States or on the American continent.

The gas cylinders and blowing cylinder are arranged in tandem; that is to say, the air cylinder is directly back of the gas cylinder. This arrangement has never been used in the United States but has been universally adopted by European gas engine builders. Undoubtedly this arrangement makes possible a much simpler design of the whole engines.

Another innovation as far as American gas engines are concerned is the use of a center crank instead of an overhung crank. While it is possible to build large engines with overhung cranks, it is considered that the center crank provides a more rigid construction; all of their large reversing engines have been built with center cranks and have been universally successful.

Finally, the blowing tub is equipped with the well known Mesta automatic plate valve (Iversen patent) which, since its introduction in 1911, has been a complete success. With these valves the efficiency of the air end is greatly increased and the cost of maintenance and repairs reduced to practically nothing, as all complicated valve gear is eliminated.

## Rapid Cyanidation of Ores

The American Rapid Cyaniding Company of Detroit, Mich., reports that they have installed a Reinohl rapid cyaniding apparatus at the Suffolk Mill, Ophir, San Miguel County, Colorado, operated by the Ophir Gold Mines, Milling and Power Company, Mr. George B. Pickett, vice-president and general manager.

Ore is run from a bin through crushers, then to a stamp mill, where it is further crushed in a cyanide solution, and conducted through a tube mill and reduced to about two hundred mesh. The pulp is then delivered to a Reinohl apparatus, comprising a launder and lixiviator, where the pulp is heated, additional cyanide supplied progressively to maintain its strength, and the pulp continuously agitated in the presence of the oxygen of the atmosphere, until contact is formed between the values and the solution.

From the end of the lixiviator the pulp is conducted to settling tanks, clarified solution bearing the values decanted, filtered and conducted through zinc shaving boxes in the usual manner. A complete cycle, from the ore bins, through the stamps, the tube mills, the Reinohl launder and lixiviator to a settling tank, clarified solution decanted from another settling tank, passed through a filter, into and through the zinc boxes, and the solution returned to the stock tank, was made in eleven minutes. Previous practice, by other cyaniding processes, required four days to accomplish the same result.

Recoveries indicated 96 per cent of the gold and 98 per cent of the silver in the ores, at a loss of 5 per cent of the strength of the solution.

Demonstrations of the process and apparatus were in charge of A. J. Weinig, engineer metallurgist of the Liberty Bell Mining and Milling Company, Telluride, Colorado, and Mr. Walter L. Reid, cyaniding engineer of the Smuggler Union Mill, Telluride, witnessed the plant in operation. The inventor, D. C. Reinohl, of Washington, D. C., superintended the installation of the apparatus, assisted by David W. Reinohl and Wesley B. Sibley.

## Obituary

**Curtis E. Whittlesey**, for many years treasurer and secretary of the McGraw Publishing Company, Inc., died at his home in Madison, N. J., on Friday, Oct. 9, 1914, in his seventy-second year. Though he had been ill of pneumonia for several days, the end came suddenly.

Mr. Whittlesey was born near Rochester in 1842. As a young man he entered business in Corfu, N. Y., where his industry and capacity brought him early success. In 1890 he joined James H. McGraw as a member of the firm which was the publisher at that time of the *Street Railway Journal*, and which, as the present McGraw Publishing Company, Inc., became also the publisher of the *Electrical World*, *Engineering Record*, and METALLURGICAL AND CHEMICAL ENGINEERING. Mr. Whittlesey had also been the treasurer of the Electrochemical Publishing Company, the former publisher of METALLURGICAL AND CHEMICAL ENGINEERING, from its early days as *Electrochemical Industry*. He was a wise counselor, conservative in his fundamental principles on the ideals of technical journalism, yet progressive in the deep personal interest which he took in the career of this journal and its ever broadening editorial scope and influence. All the members of the staff of this journal are indebted to him for innumerable kind words and acts of sympathy, advice, and encouragement.

During the twenty-four years of association with the McGraw Publishing Company Mr. Whittlesey had become widely known as a man of great experience in business affairs, and his wisdom and unerring judgment were constantly consulted not only in the affairs of the company, which he had done so much successfully to establish, but by many individuals who had come thoroughly to value his opinions on commercial and financial questions. Although his passing came with the ripeness of years, it is deeply lamented by a host of friends, many of them close business associaates, who loved and honored him. It was impossible to have even the most cursory relationship with him without being impressed by his lovable qualities and sterling character.

Mr. Whittlesey was keenly interested in church work, and was for years an elder and the treasurer of the Presbyterian Chuch at Madison, N. J.

He leaves a widow and three daughters, Mrs. Carl A. Felt, wife of the Rev. Carl A. Felt, of the Pekin University, China; Mrs. James H. McGraw, wife of the president of the McGraw Publishing Company, Inc., and Mrs. Robert E. Harned, wife of the Rev. Robert E. Harned, librarian of the Drew Theological Seminary, Madison, N. J.

* * *

**Thomas Johnston Grier**, superintendent of the Homestake Mining Co., died on the evening of September 22, 1914, at Los Angeles, Cal., where he had been with members of his family for several weeks. Although his intimate friends and associates knew that his heart was weak and that his passing would be sudden, nevertheless the news of his death came unexpectedly.

Mr. Grier was born in Pakenham, Ontario, in 1850, being the fourth of a family of ten children. He received his education in the graded and high schools of Iroquois, Ontario, and at the age of 17 learned telegraphy and was employed as an operator at Montreal. Later he removed to Corinne, Utah, and again to Salt Lake City, where he continued in the same line of work. In 1878 he entered the employ of the Homestake Mining Company at Lead, S. D., in the capacity of a telegrapher and clerk. He gradually assumed increased responsibility, and at various times was in full charge of operations during the absence of Mr. Samuel McMaster, who was then superintendent. On the death of Mr. McMaster in 1884, Mr. Grier was appointed superintendent and held that position for thirty years.

In 1886 he was married to Mary Jane Palethorpe, of Glasgow, Scotland. He is survived by his widow, a daughter and three sons.

His rise to the place of one of the foremost figures in America mining and metallurgy was from humble beginnings, and practically without that specific preliminary training which might be considered necessary. The record of his work, however, shows native ability of an unusual order in the conception and execution of large undertakings. It shows also his appreciation of, and consideration for, the human element in business, for he was always mindful of the interest and condition of his employees and made many contributions to their welfare.

It was during his term of office that the Homestake company developed into the prosperous organization that is so well known today. He directed and completed vast improvements, such as the water system that supplies the company's works, the town of Lead and several surrounding settlements. The hydroelectric power plant at Spearfish, the Ellison hoist, the Star and Amicus mills, the slime plant at Deadwood, and the viaduct connecting the mills with the company's railway system, all were completed under Mr. Grier's direction. During this period the extent of the company's operations increased greatly: the number of employees rose to about 2500 and the monthly pay roll to $250,000; the quantity of ore mined and milled reached nearly 4500 tons per day, but the management remained under his sole direction and to his discretion was left the entire policy of the company.

A suggestion of Mr. Grier's broad interest in general affairs is found in his relations outside the Homestake Mining Company. He was president of the First National Bank of Lead, vice-president of the First National Bank of Deadwood, vice-president and director of the Wasp No. 2 Mining Company and president of the Hearst Mercantile Company. He was also a charter member of the Homestake Veteran's Association, belonged to several Masonic orders and the Benevolent Protective Order of Elks. In 1892 he was elected to membership in the American Institute of Mining Engineers.

The Homestake company's policy of improving the condition of its employees and looking to their welfare is a personal tribute to the man who was its operative head for thirty years. Mr. Grier was always accessible to any employee who sought advice or a sympathetic hearing on any matter. As one of his associates has said, "in addition to his great ability, he was quite the most lovable man it has ever been my good fortune to know." Among the institutions established by the company is the hospital, the service of which is free to employees and their dependents. An Aid Fund, to which employees contribute $1 each per month, is supported by the company to the extent of $1,000 per month. This fund provides benefits in case of accident, illness or death. Recreation Hall, erected by the company at a cost of $300,000, affords a place of amusement and recreation for employees and contains the Hearst free library. Mr. Grier's interest in all these developments gave the company an enviable reputation for consideration of those who helped daily to make it one of the most famous mining organizations in the world.

In August last the Federal Commission on Industrial Relations held a hearing at Deadwood, at which Mr. Grier and others gave testimony. At the close of the hearing the chairman of the Commission made the following comment on Mr. Grier's remarks:

> "You have here the most remarkable business organization that I have come across in the country. You have developed welfare features which are beyond anything that I know of, and they are given with a liberal hand. You have a high scale of wages, reasonable hours—very fair hours. There has been evidently great progress made in taking care of the employees in the hospital service, and you have taken care of the cost of living, have kept it down below what employees in other communities have been forced to pay. You have practically been able by your great strength here as a huge corporation, dominating the whole community, to look out for the welfare of your employees, and to bring in an admirable class of citizens. It seems also that you are influential in politics, that you secure a good class of officials, and that you have secured the enforcement of law, the reduction of immorality. It seems also that you make an effort to build up the religious life of the community and that your policy is broad and liberal in all respects. I take it also, that this policy depends solely upon your personality. Such inquiries as I have made here indicate that in all cases the stockholders leave all these matters to you personally, and that this broad policy has been carried out by you on your own initiative, and that you have felt that it was necessary, for the good of the community, the securing of a fine class of labor here, which you have undoubtedly done, that you should hold the reins pretty tight on this community."

Although the Homestake Mining Company has been a recognized power in the business life of Lead and the Black Hills, still under Mr. Grier's direction that power was used wisely for the benefit of the community and never for his own aggrandizement. Perhaps few men in his position would have developed the policies in which his faith was justified, but the light of his example may well serve for the guidance of others in similar positions.

## Personal

**Mr. William R. Appleby**, dean of the Minnesota School of Mines, recently visited the mining districts of British Columbia.

**Mr. Robert S. Blair** and **Mr. Albert F. Nathan** have entered into partnership under the firm name of Blair and Nathan with offices in the Liberty Tower at 55 Liberty Street, New York City. The firm will confine its practice to the soliciting and litigating of patents and trademarks. Mr. Delos G. Haynes will be associated with the firm.

**Mr. H. A. Butz**, for the past four years chief engineer of the Dominion Iron & Steel Company, Ltd., Sydney, Nova Scotia, Canada, has severed that connection owing to the company discontinuing for an indefinite period all construction work, due to the present war conditions, and he has made no definite plans for the future. He was formerly with the Garrett-Cromwell Engineering Company, Cleveland, Ohio.

**Mr. H. M. Eastman** has recently joined the technical staff of the National Radium Institute at Denver in the capacity of assistant superintendent. **Mr. Alan Leighton** is now a member of the laboratory force of the Bureau of Mines in Denver.

**Mr. Warren R. Gillard** has resigned as chemist of the Pittsburgh Testing Laboratory to accept a position as research chemist with the Pittsburgh Plate Glass Company.

**Messrs. Gould, Free and Ash**, chemical engineers, announce that Mr. Edward E. Free has retired from the firm and that the business is being continued by Mr. Ralph A. Gould and Mr. Charles S. Ash under the firm name of Gould and Ash, with offices as formerly in the Monadnock Building, San Francisco. Mr. Edward E. Free will be at the Department of Plant Physiology, John Hopkins University, Baltimore, Md.

**Mr. J. W. H. Hamilton**, of Hamilton & Hansell and the American Grondal Company, has recently returned to New York after about one year's traveling in Europe, where he supervised the installation of several Greenawalt sintering plants.

**Mr. J. E. Johnson, Jr.**, lectured before the Franklin Institute on October 8 on the subject "Recent Developments in Cast Iron Manufacture."

**Mr. Philip Nungesser**, of the Nungesser Carbon & Battery Company, Cleveland, Ohio, recently celebrated his twenty-fifth anniversary in the dry cell business. On September 7, 1889, Mr. Nungesser sold the first dozen of his cells and got 75 cents a piece for them. At that time a few cells were sold a month. The present yearly output of dry cells in this country is estimated as 40,000,000 cells.

Mr. Charles F. Rand has resigned as president and director of the Consolidated Coppermines Company.

Mr. L. Selmi has accepted the position of chief chemist-metallurgist with the Otis Steel Company, Cleveland, Ohio.

## Digest of Electrochemical U. S. Patents

PRIOR TO 1903

*Arranged according to subject-matter and in chronological order.*

*Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.*

AQUEOUS BATH (ELECTROPLATING) *Continued*

607,646, July 19, 1898, Pascal Marino, of Paris, France.

Relates to depositing metals or alloys or to extracting metals from minerals containing them, by electrolysis in a mixed electrolyte. A solution is prepared, say, of one equivalent of that metallic salt to be deposited, selecting such salts as form insoluble precipitates with barium, strontium, calcium, or lead; and another solution of a salt of a different acid of barium, strontium, calcium, or lead, containing less than one equivalent of it. These two solutions are then mixed, and, in consequence of double decomposition, an insoluble precipitate is formed, and the remaining liquid is used as the electrolyte. In order to extract copper from a mineral the electrolyte is prepared with a solution of sulfate of copper. An alkali metal surface is added to it, and it is mixed with an insufficient quantity of chloride of an alkali-earth metal, so as not to precipitate the whole of the sulfuric acid combined with the copper and the alkali. There will be formed a sulfate of the alkali-earth metal, and the liquid, decanted or filtered, will contain only a mixture of sulfate and of chloride of copper, together with a sulfate and chloride of the alkali. To improve the conductivity and to facilitate decomposition of the mineral, I add a mineral acid, such as sulfuric or hydrochloric; the mineral containing the copper is used as an anode. When using metal anodes, a carbon anode is sometimes used with the metal.

610,954, Sept. 20, 1898, Eddy T. Thomas, of New York, N. Y., assignor to Harold Binney, trustee, of same place.

Relates to electroplating large objects, such as a ship, and consists in an open-sided tank having rubber packing edges, arranged to be temporarily secured to the object, such as a ship, the tank to contain the electrolyte. The iron body of the ship is cleaned, either mechanically or chemically, the tank secured, and an alkaline electrolyte containing a cyanide is used, since this makes a better deposit upon the iron. After the cyanide deposit, a sulfate of copper solution is used, to complete the deposit. The tank is next moved to an adjoining section and secured in a position that will produce overlapping deposits upon the ship. The anodes are removably suspended in the tank.

612,250, Oct. 11, 1898, Heinrich von der Linde, of Crefeld, Germany.

Relates to the removing of electrodeposited metal, such as nickel, copper, alloys of nickel and copper, etc., by connecting the plated metal as anode in an electrolyte of ammonium carbonate; the nickel and copper are dissolved and deposited upon a suitable cathode, the iron base of the anode not being affected by the electrolysis.

621,084, March 14, 1899, Henry L. Hollis, of Chicago, Ill.

Relates to coating iron articles such as sheets with a coating that will protect the article from rust. The article to be treated is connected as an anode in an alkaline electrolyte, such as sodium hydroxide, of specific gravity 1.25 to 1.40, temperature 50 deg. to 115 deg. C., and an anode current density of from 0.005 amp to 0.30 amp per sq. in. An iron cathode may be used, the current being interrupted when the coating is completed. The article so coated is then subjected to an annealing temperature of 800 deg. to 1400 deg. F., which changes the oxide to magnetic oxide and is so intimate with the iron that sheets may be bent without affecting the condition of the coating.

625,255, May 16, 1899, Thomas Archibald Goodchild and Archibald Campbell Tait Bond, of London, England.

Relates to the production of disappearing watermarks on manufactured paper. Upon a platinum sheet, constituting the anode, is placed moistened blotting paper or other absorbent material, and on this the paper to be marked, previously moistened through with ordinary water, for example, a water containing 20 gr. of saline matter per gallon answered the purpose. A platinum cathode of the desired design is now pressed firmly on the moistened paper for from five to ten seconds, according to the paper and strength of current. On removal of the cathode a distinct and translucent image of the design apears, which gradually fades away as the paper dries, and finally becomes invisible, but may be revived by moistening the paper. It is supposed the sodium hydroxide liberated at the cathode from the saline matter in the water acts upon the paper, the latter becoming more hygroscopic at the points of contact.

## Book Review

**The Mineral Industry**, its Statistics, Technology and Trade during 1913. Edited by **G. A. Roush**, A. B., M. S., Assistant Professor, Department of Metallurgy, Lehigh University; Assistant Secretary of the American Electrochemical Society. Octavo, 1010 pages, 55 illustrations. Price, $10. New York: McGraw-Hill Book Company, Inc.

This is the twenty-second annual volume of the famous series founded by Richard P. Rothwell and continued by such well-known editors as Joseph Struthers and W. R. Ingalls. It is interesting to note in passing that the first editor was once professor of mining in Lehigh University, and that the present editor is also connected with the same institution.

The present volume fully lives up to the reputation of its predecessors. The note in the list of contributors many of the contributors to previous volumes, and also the addition of many new names which will lend added authority to its contents. Among these new names we notice L. Addicks on Electrolytic Copper Refining, H. Foster Bain on Potassium Salts, Dr. C. G. Fink on Tungsten, B. L. Miller on Graphite, T. T. Read on the Copper Hydrometallurgy, Dr. Weintraub on Boron.

The policy of the new editor has been one of consolidation of separate articles where possible under one generic heading; also to place the articles in the hands of specialists who can handle the material authoritatively, and express valuable opinions as well as compile statistical information. In succeeding volumes we may expect still further improvements of a similar nature; but taken as it is, we can judge the present volume as worthy of the best traditions of the "Mineral Industry," and a credit alike to the capacity of the contributors and the ability of the editor.

# Metallurgical and Chemical Engineering

A Consolidation of ELECTROCHEMICAL AND METALLURGICAL INDUSTRY and IRON AND STEEL MAGAZINE

VOL. XII  NEW YORK, DECEMBER, 1914  NO. 12

PUBLISHED MONTHLY BY THE
McGraw Publishing Company, Inc.
JAMES H. MCGRAW, President.
Secretaryship vacant.
JOHN T. DEMOTT, Treasurer.
239 West 39th Street, New York.
TELEPHONE CALL, 4700 BRYANT.
CABLE ADDRESS, METCHEM, NEW YORK.

ROCKY MOUNTAIN OFFICE........421 Boston Bldg., Denver, Colo.
PACIFIC COAST OFFICE......502 Rialto Bldg., San Francisco, Cal.
CHICAGO OFFICE..........................Old Colony Building
PHILADELPHIA OFFICE................Real Estate Trust Building
LONDON OFFICE.............Hastings House, Norfolk St., Strand

E. F. ROEBER, PH.D., Editor.
H. C. PARMELEE, Western Editor.

J. M. MUIR, Manager.

*Yearly subscription price for United States, Mexico and United States dependencies,* **$2.00;** *for all other countries,* **$2.50.** (*European exchange,* **10** *shillings,* **10** *marks,* **12.50** *francs.*)

Copyright, 1914, by the McGraw Publishing Company, Inc.

Entered as Second-Class Matter at the Post Office at New York, N. Y., under the Act of Congress, March 3, 1879.

NEW YORK, DECEMBER, 1914

EDITORIAL:

Metallurgy in the Northwest.... 737
Passing the Buck .... 738
The By-product of a Chemical Reaction.... 738
Local Section Meetings of National Engineering Societies.. 738
Mexico .... 738
The Steel Trade's Prospects.... 739

READERS' VIEWS AND COMMENTS:

Fire Brick. By Chas. S. Reed and J. E. Johnson, Jr...... 740
Acceleration for Gasoline Gas Plants. By H. P. Kimber.... 740
Potatoes and Salt. By Regis Chauvenet.... 741
Cyanide Practice in the Porcupine District. By H. N. Spicer 742
The Iron & Steel Market.... 742
The Western Metallurgical Field.... 743
The Non-Ferrous Metal Market.... 745
Obituary .... 746
The Heat Balance of the Blast Furnace. By Sidney Cornell.. 747
Notes on Tube-Milling in All Slime Cyanide Practice. By W. J. Pentland .... 750
Copper in Babbitt Metal. By E. W. Hagmaier.... 753
Report of the Chemical and Dyestuff Committee of the New York Section of the American Chemical Society.... 753
Philadelphia Meeting of American Institute of Chemical Engineers Program.... 756
Chloridizing Ores at Silver City, Utah.... 757
Effect of Pickling Upon the Corrosion of Iron. By E. A. Richardson .... 759
The Gas from Blast Furnaces, Its Cleaning and Utilization. By J. E. Johnson, Jr.... 760
Treating Sulphurous Fumes at the Mammoth Smelter. By Al. H. Martin .... 769
Chemicals Produced by the Aid of Electricity.... 770
Quantitative Blowpiping as an Aid to the Prospector. By S. Fischer, Jr. .... 771
An Electrical Process for Detarring Gas. By F. W. Steere.. 775
Note on the Preparation of Pure Calcium Carbide. By M. deKay Thompson .... 779
SYNOPSIS OF RECENT CHEMICAL AND METALLURGICAL LITERATURE .... 781
NOTES ON CHEMISTRY AND METALLURGY IN GREAT BRITAIN. . 785
RECENT CHEMICAL AND METALLURGICAL PATENTS.... 788
Zirconia, A New Refractory. By H. Conrad Meyer. .... 791
The Analoid Method for the Determination of Manganese in Steel, Iron, Ore and Slag.... 793
A New High-Pressure Gas Valve.... 794
A New Vacuum Pump for Vacuum Heating and Vacuum Filtration Systems .... 795
A New Water Still .... 796
A New Electrical Long-Distance Transmitting Indicating and Recording System .... 796
Locomotive Cranes .... 798
Automatic Sampling of Mill Pulp.... 799
Personal .... 799
Digest of Electrochemical U. S. Patents.... 799
Book Reviews .... 800

## Metallurgy in the Northwest

Montana is a wonderful mineral domain; Anaconda is a metallurgical center of the first magnitude. From it have emanated innovations in the treatment of copper ore that have commanded respect and admiration, and to it have gravitated many men with faith and hope in new schemes that loomed large as possibilities but sometimes failed of realization. Within its own organization has been maintained one of the best-equipped research departments in the country. Problems have been attacked with vigorous intelligence, and the results show what can be accomplished by an organization backed by brains, money and the progressive spirit of research.

The record of the past few years is an inspiration. Beginning with the attack on slime concentration, there was evolved the twenty-deck round table and a special application of Dorr thickeners to handle daily 2500 tons of practically 200-mesh slime contained in 26,000,000 gal. of pulp. Then came the leaching experiments on sand tailing, proved on a large scale in an 80-ton unit and followed by the erection of a 2500-ton plant. The cheap production of sulphuric acid ensued as a natural development of the leaching process; and as an abundance of this material can be produced, far in excess of the demand for leaching, it is reported that the manufacture of phosphate fertilizer will be undertaken to consume the excess. Flotation is now engaging the attention of the staff and tests are being made on Minerals Separation and Callow processes. Active work on the smelter-fume problem is affording interesting developments of the Cottrell electric precipitation process, one of which is the use of pipe-treaters up to 4 ft. in diameter. The successful evolution of this method of handling fume may result in abandoning the extensive flue system and the erection of a new stack that will surpass in dimensions all previous construction of this type.

So much for copper in Montana. In the adjoining state of Idaho there is evidence that metallurgy may cut a large figure in the Coeur d'Alene lead district, where ore-dressing has held full sway. The Bunker Hill & Sullivan company has been experimenting with dry chlorination, and the president of that concern recently declared that the anticipated success of the process would mean for the Coeur d'Alenes the production of metals instead of concentrates. We hope his vision may be realized. In this connection a word of caution may not be out of place. Coeur d'Alene operators are skilled in ore-dressing; but chemistry applied to ore treatment is a very different matter, and it will require a new group of men skilled in the art to bring success. The great variety of effective work done at Anaconda is due to an organization of specialists; the same conditions must obtain in Idaho.

## Passing the Buck

A paper on a technical subject was promised for a recent joint meeting of the New York sections of several scientific societies. It was duly passed upon, as commercially harmless, by the company with which the author was connected; but presentation was prohibited at the last moment by another company with patent working arrangements with the first one.

This reminds us of the permits which are given to war correspondents by one of the allied powers and regretfully countermanded by the others.

## The By-product of a Chemical Reaction

The *Mining Magazine*, of London, comments on our editorial on the European war, but deals almost exclusively with matters which we neither said nor suggested nor hinted at. We leave the relevance and good taste of the comment of our London critic entirely to the judgment of our readers, who have our original remarks on record in our September issue for comparison of quotations and interpretation. We have no reason to modify in the least our opinions there expressed. We publish the *Mining Magazine's* comment in full as an illustration of the correctness and pertinence of our original sketch of the psychological situation:

> "Our sympathy goes to Mr. E. F. Roeber, Ph.D., editor of *Metallurgical and Chemical Engineering*. We met him last at the American Institute dinner and meeting called to do honor to Dr. Friedrich Kolbeck, of the Freiberg Mining Academy, at New York, last May. The affair had a pronounced German flavor, from the chairman's German accent to Dr. Kolbeck's speech in German, but that was no blemish then; we were glad to be present and to participate in paying a deserved compliment to the worthy representative of the great German mining school. In the September issue of his periodical, Dr. Roeber concludes that "all Europeans have suddenly gone crazy." He speaks of "crowds and nations that act under the blind forces of Nature." The war, to our genial acquaintance at New York, is a "gigantic human reaction" in which "the most celebrated individualities do not seem to have much more freedom of will than the 'free' ions of the dissociation theory." This may be a delightful chemical simile, but to us it is flavored too much with that pestilent Prussian notion that war is a 'biological necessity,' that the breaking of a treaty is condoned by necessity, that atrocities are another part of warlike necessity, and so forth, to the end of the ensanguined chapter of mad militarism. No, Dr. Roeber, this will not do. The prevalence of such ideas among educated Germans, the acquiescence of university professors in the sinister writings of the Treitschke and Nietzsche school, and the lack of protest against the vaporings of the Potsdam War-Lord are among the causes of this great catastrophe. To us the preaching of organized murder in terms of culture is an abominable impertinence. Nay more, the violation of women, the hacking of young mothers' breasts, the murder of little children, the burning of helpless captives, the shooting of inoffensive peasants in the field may be acts of individual savagery for which the General Staff and the Kaiser are not responsible, but the sacking of Louvain and the destruction of Rheims cathedral, together with several other atrocities on a large scale, are the acts of high authority, for which no excuse has been, or can be, offered. In the face of such wanton barbarism, the chemical simile of 'necessity' is an insult to human intelligence."

## Local Section Meetings

The tendency toward centralization of the activity of the national scientific and engineering societies is justified to a certain extent, but should never go so far as to detract from the great importance of the work of local sections. No legitimate expense for the conduct of the local sections should be considered too big. Local sections can accomplish in an informal way a great deal that cannot be done in a formal way nor with the necessarily cumbersome machinery of the national society.

We are glad to note the excellent work of the New York sections of the different chemical societies. Last winter the New York section of the American Electrochemical Society, under Mr. Addicks' chairmanship, did really important pioneer work in holding a series of very enjoyable and profitable joint meetings not only with the other chemical societies, but with the mining engineers, the electrical engineers, and the mechanical engineers. His present successor, Dr. Fink, followed ably with a joint meeting with the Illuminating Engineering Society and the Gas Institute, devoted to the contributions of chemistry to lighting. A full report is reserved for our next issue. Likewise the New York section of the American Chemical Society did a very creditable and timely thing through the excellent report of its Chemical and Dyestuff Committee. We are glad to print this report in full in the present issue.

## Mexico

Nothing could be more hazardous than to predict the immediate political future of Mexico. It might be a pleasant pastime for as long as a day, but it would become wearisome to watch seriously the kaleidoscopic changes taking place in the southern republic. None but a keen and enthusiastic historian would care to chronicle and remember the unnumbered shifts of fortune. And yet peace and prosperity in Mexico are of the greatest immediate importance to the mining and metallurgical industry of the United States. Industrial and mining opportunities may and do exist in South America, but there are better known and proved opportunities nearer at hand in Mexico. Here is a rich field for the investor, the manufacturer of machinery and the operating engineer. To open it would be to relieve in a marked degree the depression here due to other causes, and bring prosperity to our own country as well as Mexico.

Under the domination of Villa, northern Mexico seems to be more nearly normal than any other part of the country; but even there the resumption of business is seriously handicapped by the disorganization due to several years of revolution. Shortage of labor is the most serious item. The native Mexican has never been noted for industry and close application to work, and several years of employment as a "soldier" have not improved his qualities as a laborer.

Nevertheless resumption of operations is proceeding at some mines and smelting plants. We are informed that the American Smelting & Refining Company is again operating a few furnaces at Chihuahua, Asarco, and Monterey. The majority of cyanide mills are still closed, although in some cases the companies are keeping superintendents on the ground ready to begin work when conditions warrant.

At the time of writing there is some hope of immediate settlement of political conditions in Mexico. We recall, however, that plans for peace must involve the self-effacement of contending leaders, and it is a question whether we may reasonably expect such evidence of patriotism. That virtuous quality has not been conspicuous among Mexican revolutionists; the "liberator" is very patriotic until he sees national power in his grasp.

## The Steel Trade's Prospects

Movements in the steel trade are traditionally difficult to forecast, and that this should be the case is readily understood when one reflects that the industry has rightly been called the barometer of general trade. How shall one undertake to forecast the movements of the barometer? One rather forecasts what the weather will be by observing what the barometer has done. The essence of the principle is that steel is the foundation of so many industries, entering into nearly all the operations of men, that as one industry after another prepares for activity it buys steel, and thus the various activities are focussed upon the one spot.

Between the date of production and the date of final ultimate consumption of steel a considerable interval must usually elapse, because for most uses steel undergoes somewhat elaborate processes of fabrication. As prices rise and fall buyers endeavor to take advantage of the fluctuations and thus the quantity of steel in progress from the rolling mill to the point of final consumption undergoes wide variations, wider than is generally recognized and running into the millions of tons. For instance, there have been times when steel cars were delivered to railroads before the traffic had grown sufficiently to require them, while at other times railroads have found themselves short of cars through a portion of their equipment proving unserviceable when suddenly called upon. By reason of this tendency of the quantity of steel in transit from the rolls to ultimate consumption to vary steel mill activity has fallen into a rhythm of long swings upwards and downwards. The experienced observer has frequently been able to determine what phase the wave was in at the moment, and thus prognosticate for the future.

It is said that all signs fail in dry weather and similarly all rules have fallen down in the face of the entirely new conditions brought about by the great war. Several times in the past fifteen years the steel industry has dropped to a rate of operating 50 per cent of capacity, and the attainment of such a low rate has been the signal that the rate was shortly to increase, but now the steel mills are operating at no more than about 35 per cent of capacity, a record low rate. The character of the movement, nevertheless, has been similar to that of movements in the past, in that the volume of material in transit from the mill to the point of final utilization has shrunk to very small proportions. Confidence in values of steel and confidence that banking accommodations will be afforded have always been the forces operating to arrest the decrease and produce an increase in this volume of material. Both these forces must now be present. Steel prices are as low as they were three years ago, in November, 1911, when they reached the lowest level since the establishment of the present order of things, the lowest since 1898. To secure orders of consequence, to "start a buying movement," the mills are doubtless ready in most cases to make some further concessions. As to financial accommodations, the new Federal Reserve system, put in practical operation Nov. 16, is believed on all hands to be adequate to meet the situation.

An increase in stocks of steel in transit can afford only temporary assistance to the trade. Actual consumption and utilization must increase, and for this the various industries consuming steel must become more prosperous. It has been a state of mind, rather than a set of physical conditions that has kept industries throttled in the past few months. There has been a period of panic, of unreasoning fear, and this condition must yield, is yielding now, we believe, to analysis and recognition that in a material way we are but little injured. The observation so commonly heard of late that the tremendous destruction of property occasioned by the war is an economic loss, and must be met, is not in point at this time. The settlement must come, but it will come later. The usual effects of war are fear and prostration first, next feverish and temporary recovery, producing a "boom" towards the close of and immediately after the war, and then still later a collapse and a long period of making up for the losses.

Some industries have found already that they are benefited by the war. Few are directly injured, though many have been forced to accommodate themselves to new conditions. The recovery of most industries will be less by development of concrete conditions in material things, than by changes in the mental state, and as the minds of men are much the same whether they make breakfast food, typewriters or overalls, the change will sweep over nearly all industries in much the same manner. The mental change will be relatively swift. The war itself fits men's minds for quick changes. The consumption of steel will then increase, not perhaps to the normal average, but to a much greater rate than that of the past month or two.

The greatest cloud in the sky has been the fear that American securities held abroad would be returned in such quantities that we could not settle the account. The war, however, puts affairs on the basis of material things, no money no credit. England, for instance, would require gold only to pay for materials, and those materials must be drawn largely from this country. American manufacturers have already sold millions and millions of dollars' worth of goods to the belligerent nations, the only definite knowledge of the identity of the real buyer being the fact that the direct purchaser was a man or firm prepared to pay spot cash in New York funds.

# Readers' Views and Comments

### Fire Brick

*To the Editor of Metallurgical & Chemical Engineering:*

Sir: Referring to the article in your August issue by Mr. J. E. Johnson, Jr., as well as to my criticism and his reply which appeared in your November issue, I would like to make a further comment.

In his article Mr. Johnson states, "In very recent years fire brick manufacturers began to make furnace bricks 3 inches thick," and in the same paragraph states, "They are, therefore, very much to be preferred from practically all points of view, except that of cost. In this respect the brick makers have established certain customs, which have not been permitted to any other trade." In the following paragraph in his article he gives the reason for their so doing as being "apparently on the ground that he needs it, and he usually succeeds in getting it." This is manifestly unfair to the fire brick manufacturer in its implication.

In answer to Mr. Johnson I wish to state that the increase in the cost to the consumer of a 3-inch brick over the cost of a 2½-inch brick is based solely upon the increase in cost in manufacture. As stated in my former remarks, a brick 9 x 4½ x 2½ in. is the standard and has been for many years, and a brick of this dimension is the most economical size to make from the manufacturers' standpoint. This statement can be verified by referring to the Refractories Manufacturers Association, which is an association of fire brick manufacturers producing about 75 per cent of the fire brick manufactured in this country.

Fully 75 per cent of the fire brick manufactured are fire brick of the 9-in. series and take a base price, which includes arch, key, wedge, soap, split, etc. The remaining 25 per cent are either larger or smaller than the standard 9-in. and are for special purposes. To make a fire brick larger than the standard requires more time in both the drying and the burning, which means a loss of plant capacity.

Second, the per piece loss in both drying and burning of what is known as the blast furnace brick is approximately the same as the per piece loss of brick in the 9-in. series. As a blast furnace square is more than equal to two 9-in. brick, the loss would, therefore, be double. This statement can be verified by any fire brick manufacturer with a cost accounting system that enters into these details, which answers Mr. Johnson's statement with the reason why the fire brick manufacturer "needs it" and why "he usually succeeds in getting it."

Referring to that part of his article in which he states in relation to this increased cost that "the brick makers have established certain customs which have not been permitted to any other trade," I refer Mr. Johnson to the catalog of any steel company. The one which I have before me is headed, "Standard Classification of Extras on Steel Bars and Shapes." Immediately under this heading is a table of rounds and squares, and I note that sizes from ¾ in. to 3 in. take a base price per 100 lb. (I believe the conservative base price is $1.25 per 100 lb.) A size ⅛ in. under the minimum carries an extra of 10 cents per 100 lb. or $2 per net ton, and 3/16 in. round or square carries an extra of $2 per 100 lb. or $40 per net ton.

Referring to those shapes larger than the shapes carrying a base price 3 1/16 in. to 3½ in., 15 cents extra per 100 lb. or $3 per net ton; 6⅝ in. to 7¼ in., $1.25 per 100 lb. extra or $25 per net ton extra. The extra which the fire brick manufacturer asks for a blast furnace shape, over his price for the standard 9 in., is less than 5 cents per 100 lb. or $1 per net ton.

From the foregoing comparison, entirely based on facts, Mr. Johnson is absolutely unwarranted in writing an article inferring that the fire brick manufacturer has a moral code that is in any way inferior to that of the steel manufacturer, and the idea suggests itself to me that the least Mr. Johnson can do is to retract his statement reflecting on the business ethics of the fire brick manufacturer.

Chas. S. Reed.

Chicago Retort & Fire Brick Co.,
Chicago, Ill.

* * *

*To the Editor of Metallurgical & Chemical Engineering:*

Sir:—Referring to Mr. Reed's second letter I do not see that these comparisons of utterly dissimilar matters get us anywhere. It would be easy to show that the ratio of sizes of steel bars from the smallest to the largest which take the base price is 16 to 1 while the ratio of the sizes of firebrick on which a stiff differential is charged is only two to one. Also that the weight of the individual bars makes handling much more difficult in the large sizes owing to this vast disproportion of weight, which is not the case to anything like the same extent with brick, and that the amount of bars over three inches which are sold is insignificant as compared with the amount between that size and three-quarter inch, while the number of large brick in a furnace lining is two-thirds that of the smaller size.

But to point this out only shows the futility of Mr. Reed's comparison. I have reason to believe, however, that there may be logical and tangible evidence that it costs more to make the large brick than it does to make the small ones, though I have hitherto been unable to obtain the reasons of this from the brick manufacturers.

If I succeed now in obtaining it, I shall take pleasure in either publishing it myself or getting some reliable brick manufacturer to do it, and if it justifies their claims I shall be more than willing to admit the fact and to revise my attitude on this question. If I have done brick makers an injustice they have only themselves to thank as they have been unable or unwilling to explain on grounds that seemed reasonable to me, and I believe to most furnace men, why they charged this differential. If Mr. Reed's letters have the (very indirect) effect of causing this information to be brought out, we shall all, brick manufacturers and furnace men alike, have reason to be grateful to him.

J. E. Johnson, Jr.

New York, N. Y.

### Accelerator for Gasoline Gas Plants

*To the Editor of Metallurgical & Chemical Engineering:*

Sir:—In your issue of June, 1914, there was an article on accelerators for gasoline gas plants by Mr. C. J. Barton.

The writer has had the same experience as Mr. Barton with poor gas in the winter time with the exception that on very cold days nothing but air with a faint odor of gasoline came through the pipes.

The generator is about 30 ft. or 40 ft. from the laboratory and the compressed air, which is furnished from the plant and controlled by means of reducing valves, bubbles through the gasoline in the tank. The pipe from the generator enters the building in the basement and goes up to the laboratory.

The accelerator, which is in the basement, consists of a rectangular 2-gal. tank. The pipe from the generator enters the accelerator at the bottom and the pipe to the laboratory is in the top. With this arrangement the lean gas enters at the bottom, bubbles through the gasoline and goes directly to the laboratory through the pipe in the top.

The accelerator is fitted with a stopcock in the bottom for drawing off the non-volatile liquid and a tight-fitting plug is screwed in the top for filling.

Not more than a gallon of gasoline is ever put into the accelerator and one filling will last for two days, except in very cold weather.

The furnace for heating the building is in another part of the basement and the accelerator is partitioned off with danger signs in conspicuous places.

H. P. KIMBER.

Bridgeton, N. J.

## Potatoes and Salt

*To the Editor of Metallurgical & Chemical Engineering:*

SIR:—It is related of a certain vine grower that, dissatisfied with the modest living afforded him by the product of his labor, he consulted an oracle of his day as to a possible improvement of his fortunes.

"Dig in your vineyard for gold," was the somewhat vague answer he received. So he dug. Naturally he took care not to injure the roots of his vines. The pot of money he expected to find never came to light, but the vines renovated by the unaccustomed tillage responded with such an increase of yield that they surpassed all records, and proved to be the source of the "gold" of which the eager peasant was in search.

"Thus, my children," said the sage, in concluding his great moral illustration, "we see how we may fail to secure pecuniary emoluments by the attempted entrainment of extraordinary elements, while close at hand is an environment which properly exploited will yield to us the objects of our efforts."

For a hundred years chemists laboriously sought for phosphorus in the urine, and produced it a few grains at a time, while all the time tons of bones were available. The only trouble was they didn't know that bones contained phosphorus.

How long had man sought for a preventive or cure for yellow fever, before the humble "stegomyia," otherwise "skeeter," was discovered to be the "carrier"? And afterward, all attempts to extirpate him by death having failed, how simple and close at hand the device by which, obviating the painful necessity of his death, we gently and mercifully prevented him from being born!

Long have we dreamed, earnestly have we worked at the problem of synthetic rubber. Now a murmur is heard that it has at last "arrived." Whether as a commercial rival to the native article may indeed still be, as Kipling puts it, "another story." Many are the means proposed, but among them none is more promising, certainly not one is more simple than the method suggested by our humble title.

Potatoes! The harmless necessary spud. Salt! Condiment alike of man and beast. World-wide each, and familiar in our mouths as household words, such are the domestic elements that have modernly combined to bring about the realization of one of chemistry's most seductive fancies, artificial caoutchouc.

Here, with some reluctance, we have to announce that we cannot give proper credit for parts of the alleged discovery, and have therefore decided to make no authoritative citations. In fact, the war now raging has stopped all communications with the countries most involved, and for the time being we have to content ourselves with such fragmentary information as had been developed at the time trouble began. We believe, however, that we are correct in distinguishing the three nationalities as below stated, as well as in the statement of the leading chemical principles involved.

Starting then with the potato, we risk no denial in saying that from it comes starch. From starch man has long since learned to produce alcohol, and from alcohol the jag. However, begging our reader's pardon, we wander a little from the subject. We do not have to get as far as the jag in any logical sequence having caoutchouc for its end.

The "alcohol" thus produced is, of course, our old friend ethyl alcohol $C_2H_5OH$. But one of the obstacles in the way of its production has always been the unwelcome presence of fusel oil, so called. This is well known to the chemist as amyl alcohol $C_5H_{11}OH$. Careful study of distillation methods has limited the percentage of the fusel oil obtained. Here comes the French contribution to the new discovery. Strictly speaking, this has no scientific bearing on the problem, for fusel oil has long been well known. However, the ingenious French chemist who is now in question seems to have reasoned thus: "If we know how to get a distillation with the minimum production of fusel oil, let us instead of trying to get rid of, multiply the conditions leading to its formation."

In short, the claim is said to be fairly established that the cost of fusel oil may now be reduced in the ratio of over three to one, roughly from about 30 cents a pound to 10 cents.

"But where does your rubber come in?" Patience, we haven't got to that yet.

We must now quit the hillsides of vine-covered France and cross the Rhine. Alas, it may be that the German chemist who is responsible for the next step in the synthesis has already fallen in the brunt of battle, and his French contemporary in the stress of strife. It may be that even the English discoverer to be presently brought in has been swept away, and this terrible war may have to its debit the loss of a great industrial discovery at the very crisis of its development. For, though the outlines have been fairly set forth, it has not been claimed that commercial competition had been yet approached, albeit some of the product had been actually tested even in auto tires and had been pronounced excellent.

Our information as to the next step is scanty. This much is known, viz., that iso-amyl chloride (itself, of course, formed by the action of some chloride on the amyl alcohol) is first produced. Isoprene, the next objective point in the synthesis, has been produced from amyl alcohol. The broad statement that it is produced by the "action of chlorine" hardly satisfies the chemist's longing for technical detail. It is quite possible that some further operative detail has appeared which has escaped our attention, as we have not access to every current source of chemical information.

Isoprene is credited with the formula $C_5H_8$. Rubber has always been written as its polymer, $C_{10}H_{16}$. As usual, there was no great difficulty in getting rubber to dissociate into isoprene. There was difficulty amounting to impossibility in getting isoprene to build itself by internal molecular union into rubber!

Parenthetically, we may say that it is easy enough to represent various reactions by equations, without deriving much practical knowledge from the latter. A multitude of equations represent merely the initial and final stages of some transformation. We do not attempt here to "equate." Furthermore, we are well aware that other methods of obtaining isoprene have been published. As they do not fit into this scheme they are passed by.

Isoprene, it is claimed, has been transformed into rubber by methods which include a time element so great as to be fatal to commercial success. The latest discovery, however, eliminating the time factor as is claimed, comes from England. This has become familiar, but as we have started out to make this sketch impersonal, we can hardly violate the rule in any one case. The discovery was made as follows: Isoprene is difficult to dry, some water being so intimately intermixed or combined that it cannot be driven out by heat without decomposition of the main body. In seeking to remove the last of this water, metallic sodium was employed.

A wire of the metal was laid in a test tube filled with the liquid isoprene, the tube being corked. A remarkable catalysis developed. The isoprene polymerized into rubber!

But how does it accomplish this? It may be seriously doubted whether anyone is competent to explain mysterious reactions of this kind. The modern school regards molecules as very heavy artillery, quite unfit to open an action. But when it comes to catalysis (recently a reaction has been cited where one part in seventy millions effected the transformation), then, like Richard II, we do indeed "stand amazed." Our chemical equations seem as much out of place as catapults on a modern battlefield.

But our title is justified. Let us briefly review the steps of this synthesis.

We need not be particularly scientific or even technical to be understood.

CHAPTER I

*Potatoes.* Starch. Fusel oil. The latter more cheaply obtained than hitherto.

CHAPTER II

Fusel oil. Iso-amyl chloride. Isoprene.

*Chlorine* the essential element in this part of the evolution.

CHAPTER III

*Sodium* the efficient agent for transforming isoprene into caoutchouc.

CHAPTER IV

Chlorine and sodium form common salt. More correctly, sodium and chlorine are derived from salt.

Potatoes furnish the material. Salt furnishes the two active agencies.

Why then search air, ocean, and earth for something "new and strange" when we can find the elements for our most startling synthesis in that humblest meal of the lowly: "Potatoes and salt."

Regis Chauvenet.

Denver, Colorado.

---

### Cyanide Practice in the Porcupine District

*To the Editor of Metallurgical & Chemical Engineering:*

Sir:—I note Mr. Parmelee states in your November issue that in his article on cyaniding in the Porcupine district in the October number he had credited Dorr classifiers to the McIntyre Mill and Colbath classifiers to the Dome, whereas it should have been the reverse.

To bring the description up to date and in the interest of accuracy you may care to state that the McIntyre mill has replaced the Colbath with a Dorr classifier and has just ordered an additional one to handle their increase in capacity.

This exemplifies the difficulty of having a description correct when it is published, for Mr. Parmelee's article was probably based on his visit made last June.

H. N. Spicer.

Dorr Cyanide Machinery Co., New York City

## The Iron and Steel Market

November has been the poorest month the steel trade of the United States ever experienced. Actual purchases of steel have not equalled 25 per cent of the productive capacity, while actual production dropped from a rate of about 40 per cent of capacity at the beginning of the month to a rate of less than 35 per cent at the close.

These conditions have never before been paralleled in history.

The reduction of stocks in the hands of jobbers and manufacturing consumers has been unparalleled, the influences being a distrust of values, as steel prices were constantly falling, a doubt whether material would be needed at all in the near future, the war inducing a panic preventing judgment from being exercised, and difficulty in carrying material by reason of the almost complete lack of banking accommodations.

The war has affected the minds of men much more than it has affected material things. It did not prevent the crops maturing and it is not now greatly affecting the importation and exportation of merchandise. The collective mind has passed through many stages. Upon the announcement of war there was a sudden fright, followed by a view that prices would advance and many materials become scarce, this resulting, about the middle of August, in some price advances in steel and a small-sized buying movement. Later, with a full realization of the horrors of war and the complete dislocation of trade promised there succeeded a period of panic, of unreasoning fear, which resulted in constantly decreasing buying, up to the beginning of November, when the irreducible minimum appears to have been reached at last. Since the beginning of November the mental attitude has greatly improved. Almost everywhere a more cheerful feeling is to be observed and the greatest barrier to a recovery in trade has been removed.

Steel prices continued to fall throughout November, until at the close of the month the average level was as low as three years earlier, when the lowest point was reached since 1898. The burden upon steel manufacturers is vastly greater now than then, for wages are higher, through the general advance of early in 1913, and the cost of production is also increased by the lowness of the rate of operation, not over 35 per cent of capacity, against about 75 per cent in November, 1911.

Many steel interests have not been earning their fixed charges.

The decline in activity and prices seems now to have run its course. A mild improvement in buying is to be expected for December, and after the turn of the year more rapid progress is likely to be made. In many quarters it is believed that in April the mills will be operating at double the present rate, though few expect full operation in the industry before the close of the war.

Export trade in iron and steel has been increasing, but is still relatively light. South America was formerly our best country, but is now prostrated. The exports now being made are largely along a new line of trade, involving in large part war materials to countries that hitherto have not bought iron and steel from us in any large quantity. Barb wire, lathes, steel rounds for shrapnel, light rails with ties for portable railway, are examples of such material. Iron and steel exports in December promise to exceed 100,000 tons, against an average of 140,000 tons a year in the first six months of this year, 114,000 tons in July, 86,000 tons in August and 96,000 tons in September.

### Pig Iron

While November showed no material increase in steel buying, there was a distinct increase in pig iron buying. The Buffalo district reports large sales of foundry iron, while in the valleys and the St. Louis districts there have been fairly large purchases of basic iron by steel foundries, though practically none by steel rolling mills. Pig iron prices declined slightly about the beginning of November, but afterwards became practically stationary, at the lowest level since 1904. The rate of production, after a long decrease, appears to be approximately stationary.

The market is quotable as follows: No. 2 foundry, Birmingham, $10; delivered Philadelphia, $14.45; f.o.b. furnace, Buffalo, $12; f.o.b. furnace, Chicago, $12.50; at valley furnaces (95 cents delivered, Pittsburgh, by the recent five-cent freight advance): Bessemer, $13.75; basic, $12.50; No. 2 foundry and malleable, $12.75 to $13; gray forge, $12.50 to $12.75. England has placed conditional embargoes on manganese ore exports from India and ferromanganese exports from England, but consumption is so light that the market has not been disturbed, there being large stocks. The nominal price is $68, Baltimore.

### Steel

The market for unfinished steel has weakened even though there has been no serious enquiry to tempt reductions. It is well established that for early delivery at least billets can be had at $19 and sheet bars at $19.50, f.o.b. maker's mill, Pittsburgh or Youngstown, rods being $25, Pittsburgh. On prompt lots these prices could probably be shaded, but on the other hand it is not certain that contracts could be made at such figure for first quarter.

### Finished Steel

During the month bars, plates and shapes declined about $1 a ton, iron bars dropped irregularly and black and galvanized sheets declined $1 a ton. On November 1 the extra 2½ per cent discount to jobbers in steel pipe was removed, while the basing discount was increased one point, effecting a net reduction of about $1 a ton.

Current prices as closely as can be quoted are as follows, f.o.b., Pittsburgh, unless otherwise noted. In the Chicago district and in the east many products are sold at delivered prices equivalent to less than the Pittsburgh base prices here quoted.

Rails, standard sections, 1.25c. for Bessemer, 1.34c. for open-hearth, f.o.b. mill, except Colorado.

Plates, tank quality, 1.05c. to 1.10c.

Shapes, 1.10c.

Steel bars and bands, 1.10c.; hoops, 1.25c.

Refined iron bars, 1.20c., Pittsburgh; common iron bars, 1.10c., Philadelphia; 0.95c., Chicago.

Sheets, blue annealed, 10 gage, 1.40c.; black, 28 gage, 1.85c.; galvanized, 28 gage, 2.85c.; painted corrugated, 28 gage, 2.05c.; galvanized currugated, 28 gage, 2.90c.

Steel pipe, ¾ to 3-in., 81 per cent off list.

Standard railroad spikes, 1.35c., Pittsburgh; 1.45c., Chicago.

Structural rivets, 1.45c.; boiler rivets, 1.55c.

Cold-rolled shafting, 67 per cent off list.

Chain, ⅜-in. proof coil, 3.00c.

---

**Gas-Engine Driven Compressors.**—The C. & G. Cooper Company, of Mount Vernon, Ohio, are supplying a 950-hp twin tandem gas engine to the Medina Gas & Fuel Company for the Mansfield, Ohio, station. This will be the third Cooper unit in the plant. The Ohio Fuel Supply Company have also ordered three 475-hp single tandem gas-engine driven compressors.

## The Western Metallurgical Field

### Cyanide Consumption in the United States and Canada

For some months past there has been considerable speculation as to the quantity of sodium and potassium cyanides consumed in the metallurgical industry in the United States and Canada. Various estimates have been given, based on the tonnage of ore treated and the probable average consumption per ton of ore, but no wholly satisfactory figures have been published.

Fortunately the United States Geological Survey began in 1911 to include in its statistics on gold and silver production, the consumption of sodium and potassium cyanides, and has continued that commendable policy through 1912 and 1913. Excepting California and Oregon, data are complete for all states in which cyaniding is practiced even as a minor metallurgical process. The two states mentioned are not large consumers of cyanide, as amalgamation and smelting probably account for the recovery of the major portion of their total production of precious metals. Cyanidation is gaining a foothold in these states, but the quantity of cyanide consumed would not greatly affect the total for all states.

Neglecting definite figures for California and Oregon, and combining the figures for Texas and Wyoming with those for New Mexico and South Dakota, respectively, we believe the following table compiled from United States Geological Survey statistics, gives the most complete and reliable data yet published.

| State | 1911 Pounds | 1912 Pounds | 1913 Pounds |
|---|---|---|---|
| Arizona | 115,877 | 129,987 | 189,291 |
| Colorado | 759,149 | 837,537 | 919,963 |
| Idaho | 181,808 | 161,156 | 94,475 |
| Montana | 91,657 | 93,344 | 116,422 |
| Nevada | 2,352,961 | 2,618,424 | 2,798,224 |
| New Mexico | 165,396 | 147,035 | 207,605 |
| South Dakota | 599,845 | 580,231 | 505,142 |
| Utah | 205,041 | 203,721 | 70,238 |
| Washington | 9,700 | 36,517 | 32,090 |
| | 4,481,434 | 4,807,952 | 4,933,450 |

New Mexico for 1913 includes small quantity from Texas.

South Dakota for 1912 and 1913 includes small quantity from Wyoming.

With California and Oregon added, the grand total for 1913 would be, roundly, 5,000,000 lb. The figures given show increased consumption of 7 per cent in 1912 over 1911, and 2.6 per cent in 1913 over 1912. From 1911 to 1913 the consumption increased roundly 10 per cent. It seems likely that these figures are accurate, for while other statistical data gathered from operators may be subject to error through estimates, it is likely that individual consumers can ascertain with considerable certainty how much cyanide they purchase and use. It is to be hoped that the Geological Survey will extend this useful work in California and Oregon, so that we may know accurately how much cyanide is consumed in the treatment of precious-metal ores.

The consumption in Canada is clearly set forth in a communication from Mr. J. McLeish, chief of the statistical division of the mines branch, Department of Mines, Ottawa, as follows:

"Direct returns have not been received from Canadian mining companies with respect to their consumption of cyanide, but in view of the fact that there is no local production, a fairly accurate estimate of the consumption in Canada will be furnished by the record of imports, a detailed statement of which is attached hereto.

"The imports of all cyanides for metallurgical purposes in 1911 totaled 308 tons, or an average of about 25 tons per month. The imports in 1912 totalled 475 tons, or an average of nearly 40 tons per month. The imports in 1913 totalled 708 tons, or an average of 59 tons per month. During the first six months of 1914 the imports totalled 227 tons, or an average of only 38 tons per month, but in the month of August the imports increased to 130 tons. These figures should represent approximately the Canadian consumption of cyanide."

Imports into Canada of Cyanide of Potassium, Cyanide of Sodium, and Cyanogen Bromide for Reducing Metals in Mining Operations.

| 1913 | Pounds | Value |
|---|---|---|
| January | 84,512 | $12,648 |
| February | 10,407 | 1,192 |
| March | 160,134 | 24,174 |
| April | 77,170 | 11,566 |
| May | 80,415 | 12,235 |
| June | 178,025 | 28,197 |
| July | 71,267 | 13,784 |
| August | 183,498 | 27,802 |
| September | 89,806 | 13,556 |
| October | 208,966 | 31,559 |
| November | 142,099 | 21,026 |
| December | 129,370 | 19,433 |
| Total | 1,415,669 | $217,472 |
| **1914** | | |
| January | 177,392 | $25,363 |
| February | 134,413 | 19,270 |
| March | 143,069 | 20,116 |
| April | 82,954 | 11,540 |
| May | 193,241 | 28,113 |
| June | 96,757 | 14,038 |
| July | 96,377 | 13,333 |
| Total 6 months | 454,874 | $64,749 |
| August | 260,799 | $46,513 |
| Total for 1911 | 615,607 | $94,397 |
| Total for 1912 | 950,238 | $143,978 |

Of the gold and silver producing districts of Canada, Cobalt and Porcupine are by far the most important. According to figures compiled by Mr. A. A. Cole, mining engineer for the Temiskaming & Northern Ontario Railway Commission, Cobalt is consuming about 50 tons of cyanide per month and Porcupine about 20 tons. Mr. Cole has communicated this and other information to the Canadian Mining Institute, from the November *Bulletin* of which we taken the following notes: On the outbreak of the war it was found that with one exception all the northern Ontario mining companies were getting their cyanide from the Cassell Cyanide Company, Ltd., of Glasgow, Scotland. To this company the British government suggested the policy which is now being followed with respect to sales of cyanide, viz., to sell none of this chemical outside the British Empire until first the gold and then the silver mines within the empire have been supplied. The Cassell company is now making additions to plant, but it will be some months before increased output can be made. The price of cyanide in Ontario is now 18 cents per pound, having risen 3 cents per pound since the opening of the war. The Cassell company is now offering, however, to supply the mines with cyanide for the next two years at 18 cents per pound, and at 16 cents during 1916, providing the mines will agree to buy all their cyanide from this company alone during that time. It appears now from Mr. Cole's estimates that within a year the consumption in northern Ontario will be at the rate of 100 tons per month, or 2,400,000 lb. per year, which is almost half the 1913 consumption in the United States.

### Determining Percentage of Gold in Quartz

In a discussion before the Teknik Club, of Denver, on the subject of determining the percentage by weight of gold in a specimen of free gold in quartz, it was pointed out that at least half a dozen formulas have been published for the solution of the problem. Some of these formulas are obviously incorrect; others are of doubtful value, as their derivation is obscure. The simplest form of correct formula for solving this problem requires only a knowledge of the specific gravities of the constituents and the specimens. It is assumed, of course, that the specimen consists of practically pure constituents. If we let

$G_1$ = sp. gr. of the specimen,
$G_2$ = sp. gr. of gold, and
$G_3$ = sp. gr. of quartz.

then the percentage of gold in the specimen can be determined from the following formula:

$$x = \frac{100G_2(G_1 - G_3)}{G_1(G_2 - G_3)} \qquad (1)$$

If, for example, we have a specimen of sp. gr. 5, and take the sp. gr. of gold as 20, and of quartz as 2.5, then

$$x = \frac{100 \times 20(5 - 2.5)}{5(20 - 2.5)} = 57.1 \text{ per cent gold in specimen.}$$

If a simple arithmetical proof is required, it can be given as follows: Under the conditions assumed

| | |
|---|---|
| 1 cc gold weighs | 20 g. |
| 6 cc quartz weighs | 15 g. |
| 7 cc specimen weighs | 35 g. |

$$\text{Sp. gr. of specimen then} = \frac{35}{7} = 5$$

$$\text{Percentage of gold} = \frac{20}{35} = 57.1.$$

Another formula which has been wrongly supposed to give the solution of this problem is

$$x = \frac{100(G_1 - G_3)}{G_2 - G_3} \qquad (2)$$

Applying this formula to the problem assumed above we get 14.3 per cent, an incorrect answer. As a matter of fact, 14.3 represents the percentage by *volume* of gold in the specimen (being one-seventh, as shown above), and the percentage by weight can be calculated from the volumes and specific gravities of the constituents.

Formula (2), however, is correct for obtaining the percentage by weight of a concentrate obtained from treatment of a simple ore consisting of one mineral and gangue, when assays of ore, concentrate and tailing are known, letting

$G_1$ = Head assay,
$G_2$ = Concentrate assay, and
$G_3$ = Tailing assay.

Still another application of formula (1) is in the determination of the per cent of solids in, say a cyanide pulp, where

$G_1$ = Sp. gr. of the pulp,
$G_2$ = Sp. gr. of the dry solid, and
$G_3$ = Sp. gr. of water, or 1.

The formula then becomes

$$x = \frac{100G_2(G_1 - 1)}{G_1(G_2 - 1)}$$

### Company Reports

**Camp Bird Limited** has issued an annual report for the year ended June 30, 1914. A grave crisis in the company's affairs arose during the year due to the failure of the Canadian Agency, Ltd., Messrs. Chaplin, Milne, Grenfell & Company and Mr. A. M. Grenfell. Changes in the administration of the company since that time have resulted in economies amounting to between $9,000 and $10,000 per annum. Mr. R. J. Frecheville resigned as a director and was made chairman of the technical committee, which has charge of the company's mines. The other members of the committee are Messrs. J. A. Agnew and L. Chevrillon. In regard to the Camp Bird mine, the statement is made "that the development work in the bottom of the mine has not shown any considerable addition to the ore-reserves." In the Santa Gertrudis mine, development on the main vein at the lowest levels has not been encouraging, but on the other hand some very encouraging ore-bodies parallel to the main vein have been discovered. Ore reserves at June 30 were estimated at 1,194,000 tons. The Messina (Transvaal) Development Co., Ltd., was plunged into severe difficulties by the financial failures referred to, but is expected to solve its own financial difficulties. The estimated ore reserves developed to the ninth level are 247,000 tons of 9 per cent copper ore. The mine and plant are in first-class condition. With respect to the Central American Goldfields Syndicate, Ltd., difficulties have arisen over title to property and litigation is imminent. Operations have been suspended for the present.

The Camp Bird mill treated 30,595 tons of ore during the year, yielding an average of $26.19, as against $22.51 in the year previous. The extraction was 94 per cent. Of the total extraction, 52.97 per cent was by amalgamation, 42.07 per cent by concentration and 4.96 per cent by cyanidation. The value of the ore treated was distributed as follows: gold, 87.49 per cent; silver, 9.01 per cent; lead, 1.67 per cent; copper, 1.83 per cent. The metal content of the ore was as follows: gold, 1.135 oz. per ton; silver, 4.27 oz. per ton; lead, 1.324 per cent; copper, 0.260 per cent. The gross value recovered in the stamp mill was $761,330; net recovery, $710,234. The cyanide mill recovered $39,748 gross, or $12,379 net. Total net recovery, $722,603.

At the Santa Gertrudis property the Guadalupe mill remained closed. During the year 233 flasks of quicksilver were recovered from the old patio. The new mill was in operation until the 21st of April, when the American occupation of Vera Cruz caused a suspension of transportation facilities and an exodus of the foreign staff. The plant remained idle during the balance of the year, but was opened again on July 6, 1914. The crushing rate was 28,660 tons in July, 1913, 32,849 tons in March, 1914, and is now about 20,000 tons per month.

The quarterly report of the **Ray Consolidated Copper Co.** for the third quarter of 1914, shows an average monthly production of copper in concentrates of 4,158,384 pounds, as against an average of 6,249,448 pounds per month during the preceding quarter. Ores shipped direct to smelters contained 161,032 pounds of copper, bringing up the total production for the quarter to 12,636,185 pounds. A 50-per cent reduction in output was inaugurated August 5, due to the European war. The ore treated during the quarter averaged 1.691 per cent copper. The recovery was 67.47 per cent. The milling cost was 45.85 cents, compared with 47.24 cents for the second quarter and 53.15 cents for the first. The average mining and coarse crushing cost was 57.681 cents per ton, of which 2.814 cents was for coarse crushing. This is a reduction of 7 cents compared with the preceding quarter. The average cost of copper, after allowing for smelter losses and applying the dividends from the Ray & Gila Valley Railroad, but no other miscellaneous income as a credit to costs, was 8.849 cents per pound. If all miscellaneous incomes were credited as a reduction of cost the figure would be 8.738 cents per pound. Low costs are being maintained in spite of reduction in capacity. At both mine and mill men have been employed on alternate days in order to provide employment for the largest number and to maintain the operating organization.

**The Utah Copper Company's** report for the third quarter of 1914 shows a marked decrease in tonnage of ore treated and copper produced. The average monthly production for the quarter was 9,562,224 pounds of copper. The September production was only 6,672,194. The tonnage treated was 1,466,606 tons as compared with 2,006,157 tons for the preceding quarter. The Magna plant milled 77 per cent and the Arthur 23 per cent. Since August 7 the Arthur plant has been closed. The average grade of ore milled was 1.4356 per cent; the average extraction was 68.13 per cent. The cost per pound of copper produced was 7.76 cents, as compared with 7.539 cents in the previous quarter. Crediting miscellaneous income, the cost per pound of copper is 6.951 cents.

**The Nevada Consolidated Copper Company** shows in its third quarterly report for 1914 the same conditions of curtailment of production as indicated above for the other copper producers. The average monthly production for the third quarter was 3,752,807 pounds of copper, the output in September being 2,718,471 pounds. The output in March was 5,218,227 pounds. During the quarter 599,126 tons of ore was milled, averaging 1.52 per cent copper. In addition to this tonnage, the company also milled 11,322 tons of Giroux ore. The cost per pound of copper after crediting miscellaneous income was 9.59 cents, as compared with 10.73 cents for the previous quarter.

The reduced cost is due to the higher grade of ore treated.

The report of the **Chino Copper Co.** for the third quarter of 1914 shows a gross production of copper in concentrates of 11,491,120 pounds, as compared with 17,032,871 pounds in the preceding quarter. The September production was 3,237,869 pounds, compared with 6,109,888 pounds in April. Besides copper in concentrates there was produced in direct smelting ore 286,693 pounds of copper. The total tonnage of ore treated was 390,000, the average grade being 2,165 per cent copper. Average extraction was 68.04 per cent. The concentrates averaged 16.79 per cent copper. The cost per pound of net copper produced from milling operations, without allowing credits from miscellaneous income, was 7.81 cents. During this quarter, for the first time since the beginning of operations, the quantity of gold in concentrates was sufficient to receive consideration from the smelter. The net credit from this source amounted to 0.10 cents per pound of copper. Crediting all miscellaneous income, the cost per pound was 7.37 cents. The cost of operations is being maintained at a low figure in spite of curtailment of output; thus the cost for September, on half capacity, was 6.65 cents per pound of copper produced, without crediting miscellaneous income. The new primary crushing plant has been put in operation at the mine and has been of assistance in increasing efficiency.

## The Non-Ferrous Metal Market

Toward the end of November a distinct improvement was noted in the metal market. Prices for lead, copper and spelter advanced and more business was transacted. The London metal exchange opened on November 9. Export of copper has been affected by the British government in detaining copper shipments with the idea of preventing them from reaching a possible market in Germany. The action has caused loud protests from American copper producers, and our government has been urged to take steps to maintain such foreign market as exists.

**Copper.**—Business has been more brisk and domestic demand is good, especially among Connecticut consumers in the brass industry. Prices have been rising from 11 cents to nearly 12. The latest available quotation is about 11.87½ cents, New York.

**Lead.**—Good business has been done both in New York and St. Louis. The metal is quoted at 3.60@3.62½ cents, St. Louis, and 3.65@3.75 cents, New York.

**Tin.**—This market has been strong for immediate delivery. Spot supplies are apparently scarce and futures not in demand. The market has been active at about 34¼ cents, New York.

**Spelter.**—This metal was one of the last to share in the general market improvement, but demand has increased and prices have risen to 4.95@5.00 cents, St. Louis, and 5.10@5.15 cents, New York.

**Other Metals.**—The aluminum market continues without feature, and quotations are unchanged at 18 @18.5 cents, New York. Prices for various brands of antimony range from 12 to 18 cents, New York, with comparatively small stocks of metal available. The quicksilver market has fallen since our last report, importations from Europe having added to the supply. Flasks of 75 lb. are sold at varying prices, averaging about $43, though a wider range in bid and ask prices.

## Obituary

**William Lofland Dudley** died on September 8, 1914, en route from Clifton Springs Sanitarium to his home in Nashville, Tenn., after a sudden stroke of paralysis. He was born on April 16, 1859, in Covington, Ky., and educated in the public schools of Covington and the University of Cincinnati, from which he graduated as B.S. in 1880. (The same institution conferred on him last year the degree of Doctor of Laws.) At the University of Cincinnati he studied with F. W. Clarke, then professor of physics and chemistry. He was then demonstrator of chemistry, and after a year professor of chemistry and toxicology at the Miami Medical College of Cincinnati, which conferred on him the honorary degree of Doctor of Medicine. In 1887 he accepted the professorship of chemistry at the Vanderbilt University in Nashville, Tenn., where the main work of his life was done, until poor health forced him to retire from active work two years ago. He carried out a very large amount of chemical research leading into the most varied fields of chemical science. But he was a much bigger and broader man than a mere chemist. He was fond of art, especially music and literature, active in civic affairs, and loved clean sport. He organized the Southern Intercollegiate Athletic Association, and the athletic field at Vanderbilt University is called Dudley field. After his friend Dr. Kirkland became chancellor of Vanderbilt University, Dr. Dudley became dean of the medical school and thoroughly built it up. He never married.

* * *

**Frederick Augustus Heinze**, who for many years was a spectacular figure in the mining industry, particularly in Butte, Mont., died at Saratoga Springs, N. Y., November 4, at the age of forty-five. As a young engineering graduate of the Columbia School of Mines in 1889, Mr. Heinze went to Butte, where he subsequently founded the Montana Ore Purchasing Co. and established a profitable smelting industry. This venture was based on his firm belief that a smelting business in that district could be made a profitable business and it was the foundation of the fortune which he afterward accumulated. During his career he was involved in litigation almost constantly with the large companies of Butte, and the political history of Montana at that time gives evidence of the extent to which agencies of all kinds were involved in suits and controversies. In 1902 Heinze consolidated his interests in the United Copper Co., and about four years later the fight between him and the Amalgamated Copper Co. was terminated by the sale of his properties to this concern. After this he went to New York City and engaged in several financial ventures, establishing the Stock Exchange firm of Otto C. Heinze & Co., and purchasing control of the Mercantile National Bank. High finance was apparently breaking right for Mr. Heinze when, in 1907 his various financial houses failed and he was ousted from the presidency of the Mercantile National Bank. From the wreck of his various mining and financial ventures he saved mainly the Stewart mine in Idaho and the Mascotte tunnel in Utah.

Mr. Heinze was married in 1910 to Mrs. Bernice G. Henderson, who died within about two years. A son, F. Augustus Heinze, Jr., survives.

* * *

**David J. Kelly**, of Salt Lake City, died at his home on October 10, 1914, aged 37 years. He was a native of Utah and an engineering graduate of the University of Utah, receiving the mining engineer's degree. He was identified with various phases of the mining industry, having been assayer for the Salt Lake branch of the Kansas City Consolidated Smelting & Refining Co., and later with George Moore at Sunshine, Utah. Mr. Kelly became widely known in the metallurgical industry through his invention and development of the Kelly filter press, which finally attained prominence and success after a number of years of financial and mechanical difficulties. He is survived by a widow and two sons.

* * *

**Douglas S. Martin**, who relinquished his position on the editorial staff of the *Electrical World* in August to enroll in the forces of Great Britain, has succumbed to shrapnel wounds received at the battle of Messines on the Belgium border. Mr. Martin was graduated as an electrical engineer from the Central Technical College, London, England, and was formerly editor of the *General Electric Review*. After resigning from that paper he engaged in electrical work in the Far West, and on returning East joined the editorial staff of the *Electrical World*. Mr. Martin was twenty-seven years of age. He was a brother of Mr. T. C. Martin, secretary of the National Electric Light Association.

## International Engineering Congress

A report having been recently circulated to the effect that the International Engineering Congress, San Francisco, 1915, would be abandoned, the officers of the Congress have announced that the rumor is incorrect and that the Congress will be held as scheduled, September 20 to 25, 1915.

In view of the conditions now prevailing in Europe, the governing bodies of the five National Societies under whose auspices the Congress is to be held, have recently given careful consideration to the feasibility of holding the Congress and to the probability of its success, with the result that each body has unanimously confirmed its original pledge to support the Congress. The Committee of Management is actively proceeding with arrangements, which are now well advanced, for meetings on the scheduled dates and for the publication of the transactions.

The Committee of Management is in receipt of a sufficient number of communications from various foreign countries throughout the world, including those located within the war zone, to indicate that a large majority of the papers originally requested for presentation at the sessions of the Congress and publication in its transactions will be handed in on time, and that the Congress will be truly international in character.

**Fuel Oil.**—We have received from Messrs. Tate, Jones & Company, Inc., of Pittsburgh, Pa., their recent illustrated bulletin on Appliances for Burning Fuel Oil. After an introduction on the economies of oil as fuel and on actual results obtained with oil for steam raising and in furnace work, the first main part of the bulletin deals with standard oil burner designs, because success with oil fuel depends upon the burner. The second part describes systems for pumping, heating and regulating oil flow at burners.

# The Heat Balance of the Blast Furnace

BY SIDNEY CORNELL

Much has been written in relation to the modern blast furnace, and articles dealing with blowing in, furnace practice, and the effect of this and that condition on the furnace working are commonly seen in various papers.

Constant and systematic records are kept in most blast furnace plants of blast temperature, amount of free air blown, analysis of materials, the products of the furnace, etc., but these records seem to be for use when trouble occurs. A heat balance is useful and instructive, and can usually be figured from the data obtainable from the permanent records.

The following data was collected from a well-known plant of six 600-ton blast furnaces and average figures taken to effect the heat balance.

Table No. 1 contains the data of materials charged, together with material made, cooling water used, etc., and is arranged under the four headings: Tons per day, pounds per ton of pig iron made, tons per charge, and pounds per charge. A furnace making 445 tons of pig iron per day has sixty-four charges charged per day, which makes a period of 22½ minutes per charge. Accordingly a test period of 22½ minutes is taken and the heat balance figured accordingly.

TABLE No. 1

| | Tons per day | Pounds per ton pig | Tons per charge | Pounds per charge |
|---|---|---|---|---|
| Group No. 3 | 457 | 2,302 | 7.14 | 16,000 |
| Group No. 4 | 174 | 878 | 2.72 | 6,100 |
| Group No. 7 | 113 | 575 | 1.78 | 4,000 |
| Buffalo | 100 | 503 | 1.56 | 3,500 |
| Open hearth cinder | 57 | 287 | .89 | 2,000 |
| Flue dust charged | 20 | 100 | .31 | 700 |
| Roll scale | 20 | 100 | .31 | 700 |
| Flue dust loss | 45.5 | 230 | .71 | 1,600 |
| Coke charged | 457 | 2,302 | 7.14 | 16,000 |
| Coke breeze in yard | 7 | 34 | .11 | 240 |
| Total coke | 464 | 2,336 | 7.25 | 16,240 |
| Limestone | 205 | 1,036 | 3.21 | 7,200 |
| | (Cubic feet) | | | |
| Wind @ 90° F. cf | 42,188 | ...... | ...... | ...... |
| Pig iron made | 446.28 | 2,247 | 6.97 | 15,620 |
| Runner scrap | 1.28 | 7 | .02 | 50 |
| True pig iron | 445 | 2,240 | 6.95 | 15,570 |
| | Gallons | | | |
| Cooling water | 2,571,240 | 47,960 | 148.70 | 333,350 |
| True slag | 267 | 1,344 | 4.17 | 9,340 |

In the figuring of a heat balance two conditions present themselves, viz., whether the blast furnace gas is cleaned before using or not, and whether the blowing engines are steam operated or gas driven. In the case of gas-driven blowing engines the gas must be cleaned, and further it is reasonably certain that cleaned gas gives better efficiency in the blast furnace stoves and boilers. In the plant where this data was collected both conditions were available and accordingly the necessary data was obtained.

Table No. 2 contains miscellaneous data necessary in figuring the heat balance, temperature, etc., and Table No. 3 the analysis of materials charged and produced.

TABLE No. 3

| Ore | $LiO_2$ | $Al_2O_3$ | CaO and MgO | MnO | P. | $H_2O$ | Fe | $O_2$ | C |
|---|---|---|---|---|---|---|---|---|---|
| Group No. 3 | 6.29 | 3.53 | .18 | .63 | .066 | 13.0 | 49.40 | 21.17 | .... |
| Group No. 4 | 6.15 | 2.35 | .22 | .75 | .053 | 15.0 | 47.21 | 20.29 | .... |
| Group No. 7 | 10.50 | 3.90 | .20 | .30 | .077 | 12.0 | 45.40 | 19.50 | .... |
| Buffalo | 5.81 | 2.70 | 1.60 | .40 | .089 | 12.0 | 51.40 | 22.10 | .... |
| Open hearth cinder | 19.50 | 3.20 | 36.60 | 8.00 | .950 | 2.0 | 15.00 | 3.00 | .... |
| Flue dust charged | 8.50 | 3.70 | 3.00 | .50 | .065 | 10.0 | 50.20 | 19.07 | 9.00 |
| Roll scale | 1.00 | .10 | 1.00 | .40 | .065 | 7.0 | 66.25 | 18.00 | .... |
| Flue dust made | 9.50 | 4.11 | 3.33 | .56 | .070 | .... | 55.80 | ..... | 10.00 |

| | $LiO_2$ | Si | $Al_2O_3$ | CaO and MgO | Fe. | C. | P. | $H_2O$ | $O_2$ | S. | $N_2$ | $H_2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Limestone | 2.95 | .... | 1.00 | 53.20 | .... | ..... | .051 | 1.5 | ... | .... | ... | ... |
| Coke | 5.03 | .... | 3.18 | ..... | 1.04 | 86.08 | .023 | 2.3 | .40 | .85 | .30 | .50 |
| Pig iron | .... | 1.05 | .... | ..... | .... | 3.41 | .294 | ... | ... | .038 | ... | ... |

| | $CO_2$ | CO. | $H_2$ | $N_2$ |
|---|---|---|---|---|
| Blast furnace gas | 13.06 | 25.70 | 3.69 | 57.48 |

TABLE No. 4.

Weight taken in pounds per charge. 22½ minutes.

| Material | (Pounds) Weight | $SiO_2$ % | $SiO_2$ Pounds | $Al_2O_3$ % | $Al_2O_3$ Pounds | CaO & MgO % | CaO & MgO Pounds | MnO % | MnO Pounds | Fe % | Fe Pounds | C % | C Pounds | P % | P Pounds | $H_2O$ % | $H_2O$ Pounds | $O_2$ % | $O_2$ Pounds | S % | S Pounds | $N_2$ % | $N_2$ Pounds | $H_2$ % | $H_2$ Pounds |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Group No. 3 ore | 16,000 | 6.29 | 1,006.4 | 3.53 | 564.8 | .18 | 28.8 | .63 | 100.8 | 49.40 | 7,904.0 | ..... | ........ | .066 | 10.5 | 13.0 | 2,080 | 21.17 | 3,587 | .... | ... | ..... | ........ | .... | ..... |
| Group No. 4 ore | 6,100 | 6.15 | 375.2 | 2.35 | 143.3 | .22 | 13.4 | .75 | 45.8 | 47.21 | 2,879.8 | ..... | ........ | .053 | 3.3 | 15.0 | 915 | 20.29 | 1,238 | .... | ... | ..... | ........ | .... | ..... |
| Group No. 7 ore | 4,000 | 10.50 | 420.0 | 3.90 | 156.0 | .20 | 8.0 | .30 | 12.0 | 45.40 | 1,816.0 | ..... | ........ | .077 | 3.0 | 12.0 | 480 | 19.50 | 780 | .... | ... | ..... | ........ | .... | ..... |
| Buffalo ore | 3,500 | 5.81 | 203.3 | 2.70 | 94.5 | 1.60 | 56.0 | .40 | 14.0 | 51.40 | 1,799.0 | ..... | ........ | .089 | 3.1 | 12.0 | 420 | 22.10 | 773 | .... | ... | ..... | ........ | .... | .. |
| Open hearth cinder | 2,000 | 19.50 | 390.0 | 3.20 | 64.0 | 36.60 | 732.0 | 8.00 | 160.0 | 15.00 | 300.0 | ..... | ........ | .950 | 19.0 | 2.0 | 40 | 3.00 | 60 | .... | ... | ..... | ........ | .... | .. |
| Flue dust recharged | 700 | 8.50 | 59.5 | 3.70 | 25.9 | 3.00 | 21.0 | .50 | 3.5 | 50.20 | 351.4 | 9.00 | 63.0 | .065 | .45 | 10.0 | 70 | 19.07 | 134 | .... | ... | ... | ...... | . | |
| Roll scale | 700 | 1.00 | 7.0 | .10 | .7 | 1.00 | 7.0 | .40 | 2.8 | 66.25 | 463.8 | ..... | ........ | .065 | .45 | 7.0 | 49 | 18.00 | 126 | ... | | | | | |
| Total No. 1 | 33,000 | ..... | 2,461.4 | ..... | 1,019.2 | ..... | 866.2 | .... | 338.9 | ..... | 15,514.0 | ..... | 63.0 | .... | 39.8 | .... | 4,054 | ..... | 6,698 | | | | | | |
| Coke | 16,000 | 5.03 | 804.8 | 3.18 | 508.8 | ..... | ...... | .... | ..... | 1.04 | 16.7 | 86.08 | 13,770.0 | .023 | 3.7 | 2.3 | 368 | .40 | 64 | .85 | 136 | .30 | 48.0 | .50 | 80.0 |
| Total No. 2 | ...... | ..... | 3,266.2 | ..... | 1,558.0 | ..... | 866.2 | .... | 338.9 | ..... | 15,530.7 | ..... | 13,833.0 | .... | 43.5 | .... | 4,422 | ..... | 6,762 | | | | | | |
| To pig iron | ...... | ..... | 351.0 | ..... | ...... | ..... | ..... | .... | 300.0 | ..... | ........ | ..... | 533.5 | .... | .... | .... | ..... | MnO<br>$SiO_2$ | 68<br>186 | | | .... | ...... | .... | |
| Residue | ...... | ..... | 2,915.2 | ..... | 1,558.0 | ..... | 866.2 | .... | 38.9 | ..... | ........ | ..... | ........ | .... | .... | .... | ..... | ..... | ..... | | | | | | |
| Limestone | 7,200 | 2.95 | 212.4 | 1.00 | 72.0 | 53.20 | 3,830.0 | .... | ..... | ..... | ....... | from $CO_2$ | 818.0 | .051 | 3.6 | 1.5 | 108 | from $CO_2$ | 2,181 | | | | | | |
| Total No. 3 | ...... | ..... | 3,127.6 | ..... | 1,630.0 | ..... | 4,696.2 | .40 | 38.9 | ..... | 15,530.7 | ..... | ........ | .... | 47.1 | ... | 4,530 | ... | ... | | | .... | ....... | ... | |
| Estimated slag | 9,620 | 32.51 | 3,127.6 | 16.94 | 1,630.0 | 48.71 | 4,696.2 | .... | ..... | ..... | ....... | ..... | ........ | .0045 | .45 | .... | .... | | .... | 1.28 | 121 | .... | ....... | | |
| Flue dust made | 1,600 | 9.50 | 152.0 | 4.11 | 65.7 | 3.33 | 53.3 | .56 | 8.9 | 55.80 | 892.7 | 10.00 | 160.0 | .070 | 1.10 | ... | ... | ... | ... | ... | ... | .... | ....... | | |
| Check No. 1 | ...... | ..... | 2,975.6 | ..... | 1,564.3 | ..... | 4,642.9 | .... | 30.0 | ..... | 14,638.0 | ..... | ........ | | 46.0 | .. | ... | .... | 9,197 | | | | | | |
| True slag | 9,340 | 31.85 | 2,975.6 | 16.74 | 1,564.3 | 49.70 | 4,642.9 | .32 | 30.0 | ..... | ....... | ..... | ....... | .0018 | .45 | .... | .... | from $H_2O$ | 853 | 1.32 | 124 | ... | ... ... | from $H_2O$ | 107.0 |
| Wind | 68,000 | ..... | ..... | ..... | ..... | ..... | ..... | .... | ..... | ..... | ....... | ..... | ....... | .... | ... | 1.11 | 959 | 22.67 | 15,116 | .. | | 75.92 | 51,675.0 | | |
| Pig iron | 15,620 | Si 1.05 | 165.0 | . | | | | Mn. 1.48 | 232.0 | 93.71 | 14,638.0 | 3.41 | 533.5 | .294 | 46.0 | | | | | .038 | 6 | | | | |
| Gas | 91,283 | .... | ..... | ..... | ..... | ..... | ..... | .... | ..... | ..... | ....... | 16.19 | 13,957.0 | .... | .... | ... | ..... | 27.90 | 25,166 | .006 | 6 | 56.61 | 51,673.0 | 204 | 187.0 |

On account of the numerous chemical reactions involved it is necessary to compile an "elementary distribution" with the object in view of their final arrangement in the metal, slag, and gases. Taking each of the materials charged, their weight, and analysis, the Table No. 4 is obtained. Taking the silicon reduced from silica, the manganese reduced from the oxide, phosphorus, and sulphur, we get the arrangement in the metal, and the arrangement of the other substances in the slag and gases.

The starting point in the calculations is the hot blast, and in this test 32 deg. Fahr. is taken as the base point.

TABLE No. 2

TABLE OF MISCELLANEOUS TEMPERATURES AND OTHER DATA REQUIRED FOR THE HEAT BALANCE

| | |
|---|---|
| Tonnage of basic iron per day | 445 tons |
| Number of charges per day (average) | 64 |
| Temperature of air in blowing room | 90° F. |
| Temperature of air at snort valve | 200° F. |
| Temperature of hot blast on clean gas | 1210° F. |
| Temperature of hot blast on dirty gas | 1110° F. |
| Temperature of furnace top | 425° F. |
| Temperature of B. F. gas at stove burner, dirty gas | 280° F. |
| Temperature of B. F. gas at stove burner, clean gas | 90° F. |
| Cu. ft. free air blown per minute, test | 42,188 cu. ft., at 90° |
| Pounds of air blown during test | 68,000 |
| Hot blast pressure | 15.7 pounds |
| Cooling water used, for 24 hours = | 2,571,000 gallons |
| Average temperature difference in cooling water = | 8° F. |

## Hot Blast

HOT BLAST. AIR IN ENGINE ROOM AND STOVES

A. Air in Blowing Room.

| | # | T° | Range | | SM(o-t) | B.t.u. |
|---|---|---|---|---|---|---|
| Air (dry) | 67,041 | 90° | 58° | | 0.23421 | 910,417 |
| | | | S. P. | Range | SM | |
| Moisture (sensible). | 959 | 90° | 65° | 25° | 0.42597 | 10,212 |
| | | | B.t.u. per Pound | | | |
| Moisture (latent) | 959 | | 1101.7 | | | 1,056,530 |
| Total | | | | | | 1,977,159 |

B. Air at entrance to stove, 200° F

| | # | T° | Range | | SM (o-t) | B.t.u. |
|---|---|---|---|---|---|---|
| Air (dry) | 67,041 | 200° | 168° | | 0.23548 | 2,652,185 |
| | | | S. P. | Range | SM | |
| Moisture (sensible). | 959 | 200° | 65° | 135 | 0.43730 | 56,581 |
| | | | B.t.u./Pound | | | |
| Moisture (latent) | 959 | | 1101.7 | | | 1,056,530 |
| Total | | | | | | 4,265,296 |

C. Air through Blast Furnace Stove.

| | |
|---|---|
| Hot blast on clean gas | 1210° F. |
| Hot blast on dirty gas | 1110° F. |

Clean Gas.

| | # | T° | Range | SM (o-t) | B.t.u. |
|---|---|---|---|---|---|
| Air (dry) | 67,041 | 1210° | 1178° | 0.24715 | 19,515,635 |
| | | | B.t.u. per Pound | | |
| Moisture (latent). | 959 | | 1101.7 | | 1,056,530 |
| | | T° | Range | SM (o-t) | |
| Moisture (sensible) | 959 | 1210° | 1178° | 0.54133 | 611,554 |
| Total | | | | | 21,183,719 |

Dirty Gas.

| | # | T° | Range | SM (o-t) | B.t.u. |
|---|---|---|---|---|---|
| Air (dry) | 67,011 | 1110° | 1078° | 0.24600 | 17,779,273 |
| | | | B.t.u. per Pound | | |
| Moisture (latent) | 959 | | 1101.7 | | 1,056,530 |
| | | T° | Range | SM (o-t) | |
| Moisture (sensible). | 959 | 1110° | 1078° | .53103 | 548,931 |
| Total | | | | | 19,384,834 |

HOT BLAST (CALCULATIONS)

A.

| | |
|---|---|
| Cubic feet of air blown per minute at 90° F. | 42188. |
| Weight of air blown per cubic foot at 90° F. | .07166# |
| Pounds of air blown during charge period | 68000. # |
| Grains moisture per cubic foot air | 7.1 |
| Pounds of moisture blown in charge period | 959. # |

A. SM (o-t). 32° F. = base. 90 − 32 = 58° t-difference.

| | | |
|---|---|---|
| Air $N_2$ = 76.9 | 0.2405 + (58 × 0.0000119) = 0.24119 | 0.19547 |
| $O_2$ = 23.1 | 0.2104 + (58 × 0.0000104) = 0.21100 | 0.04874 |
| SM (o-t) | | 0.23421 |

Moisture = 7.1 grains per cubic foot. Saturation point = 65° F.

65° F. = 18.2° C. 606.5 + 0.305 (18.2) = 612.05 Kg. cal. = 1101.7 B.t.u. per #

B.

| | | |
|---|---|---|
| SM (o-t) $N_2$ = 76.9 | 0.2405 + (168 × 0.0000119) = 0.24250 | 0.18618 |
| $O_2$ = 23.1 | 0.2104 + (168 × 0.0000104) = 0.21215 | 0.04900 |
| SM (o-t) | | 0 23548 |

Moisture S.P. 18.2° C. = 1101.7 B.t.u. per # latent.

$$SM = 0.42 + 0.000103t° + 0.000103(58) = 0.42597 \qquad 0.42 + 0.000103t° + 0.000103(168) \; 0.43730$$

C. Clean Gas.

SM (o-t) = (32 − 1210°) t difference = 1178° F.

| | | |
|---|---|---|
| Air $N_2$ = 76.9 | 0.2405 + (1178 × 0.0000119) = 0.25452 | 0.19572 |
| $O_2$ = 23.1 | 0.2104 + (1178 × 0.0000104) = 0.22265 | 0.05143 |
| SM (o-t) | | .24715 |

$$SM \text{ of Moisture} = 0.42 + 0.000103t° = 0.42 + 0.000103(1178) = 0.54133$$

Dirty Gas.

| | | |
|---|---|---|
| Air $N_2$ = 76.9 | 0.2405 + (1078 × 0.0000119) = 0.25333 | 0.19481 |
| $O_2$ = 23.1 | 0.2104 + (1078 × 0.0000104) = 0.22161 | 0.05119 |
| SM (o-t) | | 0.24600 |

$$SM \text{ of Moisture} = 0.42 + 0.000103t° = 0.42 + 0.000103(1078) = 0.53103$$

## Heat Generated and Absorbed

D. Heat in Materials Charged.

| Dry Material | # | T° | Range | SM | B.t.u. |
|---|---|---|---|---|---|
| Mixed ores | 28,946 | 70 | 38 | 0.14959 | 164,529 |
| Coke | 15,632 | 70 | 38 | 0.24100 | 143,157 |
| Limestone | 7,092 | 70 | 38 | 0.20860 | 56,217 |
| Water in above | 4,530 | 70 | 38 | 1.00000 | 172,140 |
| Total | | | | | 536,043 |

From the "elementary distribution" we get the carbon actually burned and as follows:

| | | |
|---|---|---|
| Carbon in flue dust charged | 63.0 | .... |
| Carbon in coke charged | 13770.0 | .. |
| Carbon absorbed by pig iron | ..... | 533.0 |
| Carbon in flue dust made | ... | 160.0 |
| Total | 13833.0 | 693 0 |
| Carbon burned | 13139.0 | |

Heat in carbon burned = 14,544 × 13,139 = 191,093,616 B.t.u.

H. Heat in Gas Made.

From the "elementary distribution," or burden sheet, there is made 91,283 pounds of gas, containing 13,957 pounds of carbon in it. Analysis of gas made averaged 13.06 $CO_2$ and 25.70 CO, and keeping this ratio intact, namely 55% CO, to 45% $CO_2$ by volume, we get the following:

| | FROM BURDEN SHEET | | | AVERAGE FROM TESTS | |
|---|---|---|---|---|---|
| Gas | Pounds | % Weight | % Volume | % Volume | % Weight |
| $CO_2$ | 17,260 | 18.91 | 12.50 | 13.06 | 19.83 |
| CO | 21,903 | 23.99 | 25.07 | 25.70 | 21.68 |
| $O_2$ | 254 | .278 | .25 | ... | ... |
| $H_2$ | 187 | .204 | 2.97 | 3.69 | .25 |
| $H_2S$ | 6 | .006 | .005 | .. | |
| $N_2$ | 51,673 | 56.610 | 59.205 | 57.48 | 55.24 |
| Total | 91,283 | | | | |

| | |
|---|---|
| B.t.u. per # = 1187.5 | 1252.91 |
| B.t.u. per cubic foot @ 32 = 97.82 | 102.53 |
| Weight per cubic foot @ 32 = .08215 | .08179 |
| Cubic feet per pound = 12.11 | 12.22 |

| | | | | |
|---|---|---|---|---|
| Pounds | | B.t.u. Pound | | B.t.u. |
| 91,283 | | 1187.5 | | 108,398,562 Latent |
| Pounds | T° | Range | SM (o-t) | |
| 91,283 | 425° | 393° | 0.21580 | 8,817,938 Sensible |
| Moisture | T° | B.t.u. # | Total B.t.u. # | B.t.u. |
| 4530# | 425 | 1115.8 | 1261.4 | 5,714,142 |

| | T° | S. P. | Superheat | SM | B.t.u. # |
|---|---|---|---|---|---|
| 4530# | 425 | 111° | 314° | 0.463775 | 145.6 |

Total B.t.u. in the gas 122,930,642

E. Heat Absorbed in Reduction.

| Material | Pounds | B.t.u. per # | B.t.u. |
|---|---|---|---|
| Silicon | 165 | 11,571 | 1,909,215 |
| Manganese | 232 | 4,100 | 951,200 |
| Iron | 14,638 | 3,143 | 46,007,234 |
| Phosphorus | 46 | 10,605 | 487,830 |
| Liberation of $CO_2$ | 2,999 | 1,710 | 5,128,290 |
| Dissociation of $H_2O$ | 959 | 5,740 | 5,504,660 |
| Total | | | 59,988,429 |

F. Total Heat in Metal, Slag and Flue Dust

| Material | Pounds | B.t.u. per # | B.t.u. |
|---|---|---|---|
| Basic metal | 15,620 | 450 | 7,029,000 |
| Slag | 9,340 | 692 | 6,463,280 |
| Flue dust | 1,600 | 130 | 208,000 |
| Total | | | 13,700,280 |

G. Heat Carried Off in Cooling Water.

333,350 × 8 = 2,668,400 B.t.u.

H. Calculations.

| Gas | % Weight | Standard Weight | | % Volume | At 32° Weight, Cu. Ft. | B.t.u | B.t.u. Cu. Ft. |
|---|---|---|---|---|---|---|---|
| $CO_2$ | 18.91 | 0.12421 | 15.22 | 12.50 | .01553 | .. | .. |
| CO | 23.99 | 0.07858 | 30.52 | 25.07 | .01970 | 3.49 | 87.49 |
| $O_2$ | .278 | 0.08953 | .31 | .25 | .00022 | .. | . |
| $H_2$ | .204 | 0.00565 | 3.62 | 2.97 | .00017 | 3.48 | 10.33 |
| $H_2S$ | .006 | 0.09642 | .006 | .005 | .000005 | .. | .. |
| $N_2$ | 56.610 | 0.07859 | 72.03 | 59.205 | .01653 | ... | . |
| | | | 121.706 | | .082155 | | 97.82 |

Average from Tests.

| Gas | % Volume | Standard Weight | | % Weight | At 32° Weight Cu. Ft. | B.t.u. | B.t.u./Cu. Ft |
|---|---|---|---|---|---|---|---|
| $CO_2$ | 13.06 | 0.12421 | 1.622 | 19.83 | .01622 | ... | ... |
| CO | 25.70 | 0.07858 | 2.019 | 21.68 | .02019 | 3.49 | 89.69 |
| $H_2$ | 3.69 | 0.00563 | .021 | .25 | .00021 | 3.48 | 12.84 |
| $N_2$ | 57.48 | 0.07859 | 1.517 | 55.24 | .01517 | . | .... |
| | | | 8.178 | | .08179 | | 102.53 |

SM of Gas.

| | | | | |
|---|---|---|---|---|
| $CO_2$ | 18.91 | 0.1900 + 393 × 0.00006 | 0.21358 | 0.04039 |
| CO | 23.99 | 0.2405 + 393 × 0.0000119 | 0.24517 | 0.05881 |
| $O_2$ | .278 | 0.2104 + 393 × 0.0000104 | 0.21448 | 0.00059 |
| $H_2$ & $H_2S$ | .210 | 3.3700 + 393 × 0.000170 | 3.43681 | 0.00722 |
| $N_2$ | 56.610 | 0.2405 + 393 × 0.0000119 | 0.24517 | 0.13879 |
| SM | | | | 0.21580 |

91 283# Dry Gas @ .08215 # per cubic foot 1,111,174 cu. ft.

## Hot Blast Stoves

Two cases of use of the gas now present themselves: Cleaned or Dirty Gas used in Blast Furnace Stoves. The following data was taken from stoves, and in which operation 3 stoves are continually used on gas, and 1 stove on air.

| | Cleaned Gas | Dirty Gas |
|---|---|---|
| Pounds of gas per charge | 24,100 | 26,500 |
| Temperature at burner | 90° | 280° |
| Grains of moisture per cu. ft | 14 2 | 28.5 |
| Saturation point | 90° F. | 111° F. |
| Pounds of moisture in gas | 595. | 1313. |

J. Heat in Gas Burned in Stoves.

Cleaned Gas.

| # | | B.t.u./# | B.t.u. |
|---|---|---|---|
| 24,100 | | 1187.5 | 28,618,750 |
| Moisture | T° | B.t.u. # | |
| 595 | 90 | 1101.7 | 635,511 Latent |
| | | | 29,254,261 |

S.P. =90, hence no superheat

Dirty Gas.

| # | | | | B.t.u./# | B.t.u. |
|---|---|---|---|---|---|
| 26,500 | | | | 1187.5 | 31,468,750 |
| Moisture | T° | S.P.° | Range ° | SM | B.t.u. |
| 1313 | 280 | 111 | 169. | 0.24263 | 53,742 |
| | | | | B.t.u. | |
| 1313 | | | | 1115.8 | 1,463,045 |
| | | | | | 32,985,537 |

B.T.U. IN GAS BURNED IN STOVES

| Clean Gas | Dirty Gas |
|---|---|
| 29,254,261 | 32,985,537 |

## Blowing

The following facts were observed in connection with the Blowing Engines, Boilers, and other auxiliaries in connection with the Blast Furnace Plant:

A. Gas Blower required 8775# of gas to blow the air required per charge period.

A. Gas Electric Set required 15# of gas per KWH.

It required 1.7# of Dirty Gas to evaporate 1# of steam at 140#.

It required 1.6# of Clean Gas to evaporate 1# of steam at 140#.

Steam Blowing Engines consumed 25,000# of steam per charge period to blow the air required as found from water rate figured from indicator cards.

Available Gas. Conditon A.

| Dirty Gas | Pounds Dry Gas | B.t.u. |
|---|---|---|
| Out of furnace top | 91,283 | 122,930,642 |
| Leakage and bleeding, 10% | 9,128 | 12,293,064 |
| To stoves, dirty gas | 26,500 | 32,985,537 |
| Remaining to boilers | 55,655 | 77,652,041 |
| Steam generated, pounds | 32,740 | 39,091,560 |
| Blowing engines ......Steam u ed | 25,000 | 29,850,000 |
| Steam pumps " " | 5,000 | 5,970,000 |
| Water pumps " " | 500 | 597,000 |
| Hoists " " | 2,000 | 2,388,000 |
| Total | 32,500 | 38,805,000 |
| Surplus | 240 | 286,560 |

Steam at 140# gage has 1194 b.t.u. total heat per #.

The above condition is a Steam Blown Blast Furnace with all auxiliaries using steam, and it may be noted that there is practically use for all the steam generated at the furnace itself.

Available Gas. Condition B

| Cleaned Gas | Steam Blown<br>Pounds Dry Gas | B.t.u. |
|---|---|---|
| Out of furnace top | 91,283 | 122,930,642 |
| Leakage and bleeding, 10% | 9,128 | 12,293,064 |
| To clean gas at cleaners | 82,155 | 99,794,411 |
| Loss of heat in cooling | ..... | 10,843,167 |
| To stoves | 24,100 | 29,254,261 |
| Remaining | 58,055 | 70,540,150 |
| team generated | 44,660 | 53,324,040 |
| Blowing engines | 25,000 | 29,850,000 |
| Steam pumps | 5,000 | 5,970,000 |
| Water pumps | 500 | 597,000 |
| Hoists | 2,000 | 2,388,000 |
| Total | 32,500 | 38,805,000 |
| Surplus | 12,160 | 14,519,040 |

Calculation of heat after cleaning is similar to calculation under J or

| # of Gas | B.t.u./# | Total |
|---|---|---|
| 82,155 | 1187.5 | 97,559,062 |
| 2,029# $H_2O$ | 1101.7 | 2,235,349 |
| Total | | 99,794,411 |

Steam generated =58,055# of gas ÷1.3 =44,660.#

Available Gas. Condition C. Gas Engines

Cleaned Gas.

| | Pounds Dry Gas | B.t.u./# | B.t.u. |
|---|---|---|---|
| Out of furnace top | 91,283 | | 122,930,642 |
| Leakage and bleeding, 10% | 9,128 | | 12,293,064 |
| Cleaned gas through cleaners | 82,155 | | 99,794,411 |
| Loss of heat in cleaning | ..... | | 10,843,167 |
| To stoves | 24,100 | | 29,254,261 |
| Remaining | 58,055 | | 70,540,150 |
| Gas blowers for furnace | 8,775 | 1213 | 10,644,075 |
| Auxiliaries take 3000# steam = | 4,800 gas | | 5,822,400 |
| Electrical use | 44,480 gas | | 54,073,675 |

| | KWH | B.t.u. | |
|---|---|---|---|
| 44,480# gas = | 2,965 | 3412 | 10,116,580 |

It was stated that the furnace tested was one rated at 600 tons of pig iron per day. During the week in which these simultaneous observations were taken 445 tons of pig iron were made per day, this being basic pig iron, and which is a fair figure for such practice. It was not desirable to make any unnecessary assumptions in the conditions, and accordingly the facts were taken as they were observed.

II. Calculations.

| | |
|---|---|
| 4,530# Moisture @ 7000 grains per lb | 31,710,000 grains |
| Grains moisture per cubic foot @ 32° | 28.5 |
| Saturation point =111° F | 44° C. |

SM (o-t) = 0.42 +0.000103t°

B.t.u. =606.5 +0.305(44) = 619 92 Kg. Cal.
=1115 8 B.t.u.

SM =0.42 +0.000103(425)
=0.42 +0.043775
=0.463775

SM (o-t). T =280° −32 =248.

| | | | | |
|---|---|---|---|---|
| $CO_2$ | 18.91 | 0.1900 +248 ×0.00006 | 0.20488 | 0.03874 |
| CO | 23.99 | 0.2405 +248 ×0.0000119 | 0.24345 | 0.05840 |
| $O_2$ | .278 | 0.2104 +248 ×0.0000104 | 0.21298 | 0.00059 |
| $H_2$ & $H_2S$ | .210 | 3.3700 +218 ×0.000170 | 3.37421 | 0.00708 |
| $N_2$ | 56.610 | 0.2405 +248 ×0.0000119 | 0.24345 | 0.13782 |
| | | SM | | 0.24263 |

It may also be observed that the coke figure is high, and there are some furnaces with a better record and many with a worse record of coke consumption than this, but inasmuch as a furnace superintendent is greatly elated when a low figure for coke is obtained and is otherwise when it is the reverse, this figure is taken as representative.

The tabulated figures are given together with the calculations involved in each step, treating hot blast, the heat generated and absorbed, and the gas made separately.

In considering the use of the gas for power purposes in the operation of the furnace three conditions were available and on which data was obtainable.

Condition A was one in which the furnace was blown by steam-driven units, and this steam generated in boilers burning uncleaned or dirty gas. The efficiency of this system is obvious, and not economical, and accordingly a very little surplus steam for sale or use in the steel plant was available. It seems that exhaust steam turbines would be a profitable addition to such an equipment.

In condition B, and in which the blowing engines and auxiliaries were steam driven, the steam being generated in boiler burning cleaned gas, cleaned gas also was used in the stoves. The efficiency is much better. Although this system is conductive to better operation, and gives an appreciable amount of surplus steam for sale, still from a financial standpoint, considering the investment necessary for a cleaning equipment, and the fact that labor saved on the stoves and boilers would have to be used in the cleaning plant, it is doubtful if it would reduce cost of operation. However, economy could be obtained by using exhaust steam turbines.

In condition C, the use of gas engines shows the outcome of this advanced step towards economical use of the gas from a blast furnace. Some of the auxiliaries still use steam, but since there were six furnaces in the plant where this furnace was tested and all three conditions were present it was possible to figure the amount of steam used for pumps, etc., easily. This condition also represents the exact conditions on the furnace tested, namely, blown by gas engines, water pumped by steam pumps, and hoists operated electrically, as were the auxiliaries in the cleaning plant. Deducting the gas used in the stoves, in the gas engine blowers, and for use in the auxiliaries, there was remaining some 44,480 lb. of gas, which yielded 2965 kw-hours in electrical units, through a gas engine generating set, and at an efficiency of 18.7 per cent. Further economy could still further be obtained if use were made of the heat in the exhaust of the gas engines, and much steam generated which could be used in low-pressure turbines.

The three conditions tabulated make it a simple matter to figure the use of exhaust steam turbines applied to further economy. This question has been and still is very much discussed. It would be interesting to see just wherein the economy would balance best, in

## Conclusion

HEAT BALANCE

| | STEAM BLOWN FURNACE WITH DIRTY GAS A. | | STEAM BLOWN FURNACE WITH CLEANED GAS B. | |
|---|---|---|---|---|
| | B.t.u. | % | B.t.u. | % |
| Air in blowing room | 1,977,159 | .94 | 1,977,159 | .92 |
| Air at entrance to stoves | 4,265,296 | 2.02 | 4,265,296 | 2.00 |
| Air through stoves | 19,384,834 | 9.18 | 21,183,719 | 9.95 |
| Heat in materials charged | 536,043 | .25 | 536,043 | .25 |
| Heat in carbon burned | 191,093,616 | 90.57 | 191,093,616 | 89.80 |
| Total | 211,014,493 | 100 | 212,813,378 | 100 |
| Heat of reduction | 59,988,429 | 28.44 | 59,988,429 | 28.19 |
| Heat in slag, metal and flue dust | 13,700,280 | 6.49 | 13,700,280 | 6.43 |
| Heat in cooling water | 2,668,400 | 1.26 | 2,668,400 | 1.25 |
| Heat in gas made | 122,930,642 | 58.26 | 122,930,642 | 57.78 |
| Total | 199,287,751 | 94.45 | 199,287,751 | 93.65 |
| Loss due to radiation, etc. | 11,726,742 | 5.55 | 13,525,627 | 6.35 |
| Loss to cooling of gas | ......... | ...... | 10,843,167 | 5.09 |
| Loss due to gas leakage | 12,293,064 | 5.82 | 12,293,064 | 5.77 |
| Gas to stoves | 32,985,537 | 15.63 | 29,254,261 | 13.74 |
| Gas to boilers | 77,652,041 | 36.81 | 70,540,150 | 33.14 |
| Heat in steam made | 39,091,560 | 18.52 | 53,324,040 | 25.05 |
| Heat in steam to blowers | 29,850,000 | 14.14 | 29,850,000 | 14.02 |
| Heat in compression of air | 2,288,137 | 1.08 | 2,288,137 | 1.08 |
| Heat in steam to auxiliaries | 8,955,000 | 4.24 | 8,955,000 | 4.20 |
| Heat in surplus steam | 286,560 | .14 | 14,519,040 | 6.82 |

| | GAS BLOWN FURNACE, CLEANED GAS C. | |
|---|---|---|
| | B.t.u. | % |
| Air in blowing room | 1,977,159 | .92 |
| Air at entrance to stoves | 4,265,296 | 2.00 |
| Air through stoves | 21,183,719 | 9.95 |
| Heat in materials charged | 536,043 | .25 |
| Heat in carbon burned | 191,093,616 | 89.80 |
| Total heat | 212,813,378 | 100 |
| Heat of reduction | 59,988,429 | 28.19 |
| Heat in slag, metal and flue dust | 13,700,280 | 6.43 |
| Heat in cooling water | 2,668,400 | 1.25 |
| Heat in gas made | 122,930,642 | 57.78 |
| Total | 199,287,751 | 93.65 |
| Loss due to radiation, etc | 13,525,627 | 6.35 |
| Loss due to gas leakage | 12,293,064 | 5.77 |
| Loss due to cooling of gas | 10,843,167 | 5.09 |
| Gas to stoves | 29,254,261 | 13,74 |
| To gas blowers | 10,644,075 | 5.00 |
| To auxiliaries | 5,822,400 | 2.73 |
| To electrical units | 54,073,675 | 25.41 |
| Converted into electricity | 10,116,580 | 4.75 |

Efficiency of Blowing Engines.

| | Air Blown | Heat Delivered | Heat Gain | Efficiency, % |
|---|---|---|---|---|
| Steam blowers | 67,041 | 29,850,000 | 2,288,137 | 7.66 |
| Gas blowers | 67,041 | 10,641,075 | 2,288,137 | 21.49 |

Efficiency of Stoves.

| | Heat in Air Entering | Gas Burned | Hot Blast | Efficiency, % |
|---|---|---|---|---|
| Clean gas | 4,265,296 | 29,254,261 | 21,183,719 | 57.8 |
| Dirty gas | 4,265,296 | 32,985,537 | 19,384,834 | 45.9 |

Conclusion.

| Condition | A. | B. | C. |
|---|---|---|---|
| Work of reduction, melting and hot blast | 43.17% | 43.65 | 43.65 |
| Work of cooling furnace | 1.26% | 1.25 | 1.25 |
| Radiation loss | 5.55 | 6.35 | 6.35 |
| Gas leakage loss | 5.82 | 5.77 | 5.77 |
| Loss of heat in stoves | 8.47 | 5.79 | 5.79 |
| Loss of heat in boilers | 18.29 | 18.09 | ..... |
| Loss of heat in cooling gas | ..... | 5.09 | 5.09 |
| Heat in steam made | 18.52 | 25.05 | ..... |
| Steam used by furnace | 18.38 | 18.22 | ..... |
| Steam heat salable | .14 | 6.82 | ..... |
| Heat in gas cleaned and used in blowers | | | 5.00 |
| Heat in gas cleaned and used in auxiliaries | | | 2.73 |
| Heat in gas to electric units | | | 25.41 |
| Conversion of available gas into electricity | | | 4.75 |

connection with steam blowing engines or with gas blowing engines and generator sets.

In the conclusion it may be noted that the stove efficiency on clean gas is 57.8 per cent and on dirty gas 45.9 per cent. The stoves themselves are open to much discussion, and the relative economy of two or three-pass stoves is an open question. The ratio of checker work is absurd when comparisons are made, and the relative value of side or central combustion chamber type of stoves has not been settled.

It seems that there is a very fertile field for effecting important improvement, and the figuring of heat balances under representative conditions should settle these points:

In all applications of new apparatus or remodeling of old, it is necessary to consider investment with the economy effected.

The regular operation obtained by using the dry blast is an example of a large investment required to effect large savings.

---

# Notes on Tube-Milling in All-Slime Cyanide Practice

BY W. J. PENTLAND

There seems to have been a general agreement among writers on the subject of tube-milling for cyanidation that the most desirable moisture content of the pulp is 38 (and sixteen decimals) per cent. It is true that many accounts have been published that seem to demonstrate this figure the ideal one. It is true also, we believe, that almost all of the tube-mills used in the experiments on correct moisture content were of the trunnion, small-discharge-opening type. Many of the early ideas on tube-milling no longer hold good. For example, it used to be said that "the finer the feed going to the tube-mill, the greater amount of net fine grinding done," and "the longer the pulp can be kept in the mill, the finer it will be ground." Many such comments were considered sound once, but are no longer heard. We believe it not improbable, therefore, that the old standard of 38 (and so many decimals) per cent moisture may go the way of some other assumptions. We now find many operators specifying 35 per cent moisture as preferable; to-morrow they will be saying 33 per cent, and may some time hold to 30 per cent.

Individual experiments are helpful, but they are not conclusive. Experimental conditions are rarely realized in practice. We endeavor to have practical conditions in our experiments, but rarely get them. Then we are apt to persuade ourselves that in subsequent practice we have the conditions of the experiments. Further, design of machinery and methods of operation change from time to time, and the standards of one period become untenable as practice in an art progresses. Thus, all early tube-mills were of the trunnion type; then came the tire type, with large discharge opening; and now we witness the Chalmers & Williams idea of inserting lifters behind perforated liner plates at the discharge end of the tube, virtually giving a discharge area of the whole diameter of the tube-mill.

In determining proper tube-milling conditions, it is one thing to have a single tube in a plant and be able to vary the system with facility, and quite another to have ten, twelve or fourteen tubes without equal facility in varying conditions. In the latter case it is usually necessary to decide upon a system and then carry it out over a period of a month or more and judge the average results. We believe that this method is likely to give more reliable information, as the experiment is subject to true working conditions.

It is usually true that a pulp must contain 38 per cent moisture in order to "get it through" the tube, or to "make the tube handle it," but not necessarily grind it to the required degree of fineness. Under such conditions we discharge the pulp to a classifier so that the unground portion may be returned to the tube-mill, and this is done because more work is demanded of the tube-mill than it can do under the conditions prescribed. In this respect the tube-mill is to be compared to a launder transporting pulp. If it is set practically level, as in the small-discharge-opening type, the more ore it has to handle, the more moisture must be supplied to transport the ore. The greater the inclination, or difference in fall between feed and discharge, the more ore can be passed as a thick pulp, or, in other words, the percentage of moisture required to carry it can be reduced.

### Duty of the Tube-Mill

It is a perfectly legitimate subject for debate whether the load going to the tube-mill should be in excess of the tube's capacity for grinding to the requisite degree of fineness, necessitating the return of a part of the pulp for regrinding, or be so adjusted that all of the required grinding is done in one passage of the pulp through the tube. If we are depending on the tube-mill to act as part of the agitation system, we may be compelled to return part of the pulp, but there are more economical agitators than tube-mills. If we can obtain proper grinding with one passage of the pulp through the tube, and also secure some agitation and dissolution of metal at the same time, we can well afford to build the subsequent agitators a little larger to secure dissolution of the metal that would have taken place in the tube-mill if we had returned part of the pulp to it.

The use of a closed circuit in tube-milling has become general practice, and this feature is closely related to the custom of grinding in 38 per cent moisture, for under no conditions will pulp of that moisture content pass through a tube-mill and be properly ground for all-sliming. At the same time we believe that there is no fixed and unalterable reason for returning part of the pulp to the tube-mill. It is the custom; just as it is custom, also, to use 38 per cent moisture. The advocates of this practice claim that if thicker pulp be fed to a tube-mill the machine will become "constipated" and will be unable to handle sufficient tonnage, and so for mechanical reasons it is necessary that the pulp be more dilute. As a matter of fact, this claim tells us exactly what is the matter with tube-mills of small discharge openings. It is admitted that such mills will not grind a sufficient tonnage of low-moisture pulp, and so we dilute it and circulate it through and through the mill until it is sufficiently ground.

### An Experiment with Graded Pulps

A simple experiment can be performed that will give some light on what takes place in a tube-mill. Take battery sand practically free from slime as it comes from the discharge of a classifier, and screen it into a number of sizes at intervals of 10 points between 10-mesh and 150-mesh. With each size make a pulp containing 38 per cent moisture, and by agitation of some kind keep the solids in suspension so that the pulp shall be of uniform consistency throughout. Then, commencing with the coarsest grade, take a sample of each pulp on a spatula. A certain quantity of the coarsest grade can be raised and retained on the spatula. Of the succeeding sizes less and less can be raised until, in the case of the 150-mesh pulp, scarcely any can be secured because the accompanying moisture affords sufficient carrying medium to keep the solids in suspension. Or, if each of the pulps were to be dumped on a flat surface, we would find that almost all of the coarsest grade would remain on the plate. There would be successively smaller quantities of the finer grades, and as we approached 150-mesh we would find more and more of the ore carried away in suspension, even with 38 per cent moisture.

We believe that this experiment indicates what occurs in a tube-mill. With the same percentage of moisture, finer sizes of sand are kept in suspension among the pebbles; and even though the whole mass of pebbles and pulp be rolling and grinding, the finer sands are still in suspension and sluicing around in the voids. The coarser sands are picked up by the pebbles and remain on their surfaces because the accompanying moisture is not sufficient to keep them in suspension. They are then in favorable position to be caught between pebbles and receive the requisite amount of grinding. We think that the pulp should be thick enough to permit the sand particles to cling to the pebbles as they rise with the mill. When the pulp is so thin that no particles cling to the pebbles, poor work is being done, and only the coarse sand is being satisfactorily ground.

It is readily seen that such thick pulp will not flow through a tube-mill that has feed and discharge openings at practically the same level; but it will flow when the discharge is lower than the feed, according to the difference in levels. Tube-mills of small discharge opening were responsible for the standard of 38 per cent moisture; and, in turn, adherence to that standard is responsible for the present tendency toward shortening tube-mills, from 20 feet and more, to 16 feet. With 38 per cent. moisture it is only of the coarser sands that the due proportion is ground, and that grinding takes place near the feed end of the mill. Then the remaining length of a long tube gives little service as a grinder and acts mainly as an agitator; therefore we shorten the tube, classify the ground pulp and return the oversize in the hope that it also will be duly ground in its next passage through the mill.

Diameter is an important factor in tube-mill design, but it is not "the whole thing," and increased diameter has the disadvantage of requiring more power for starting the mill. There is a tendency at present to regard sixteen feet as the most desirable length, on the assumption that practically no grinding is done beyond this point, making additional length useless. Some operators are inclined to believe that this is a mistaken idea, and that with thick pulps, or low moisture content, and a low discharge level, longer mills can be made to do satisfactory work. There is an advantage in using large units, but there is a limit to the practicable diameter, and greater capacity can then be had only by increasing the length.

### Cones Versus Drag Classifiers

At one time is was customary to use cones for thickening tube-mill feed; but these devices gave trouble from the beginning, and only by unremitting care and attention could they be made to furnish pulp even as thick as 38 per cent moisture. We believe, however, that as drag classifiers displace cones, and operators have thicker pulps to experiment with, they will regard them as more desirable. As tire-type mills come into greater use, the advantage of quicker discharge will be observed; and those who have condemned the long tube-mills will try discharging with the lifter device over the whole diameter of the tube, and will find that the long mills will grind a larger tonnage than the shorter ones.

Fresh battery sand is easier to grind to slime than is returned sand that passed through the tube-mill and classifier. The former is sharp and angular; the latter is rounded. The former can be more readily dewatered than the latter, and will be more readily picked up by the pebbles in the mill. This can be demonstrated practically by comparing the work of tube-mills on sand from old tailing dumps and fresh battery sand from the same ore.

### Effect of Size of Feed on Capacity

It has been observed that some operators deceive themselves as to the net work their tube-mills are doing. If they are treating 100 tons of ore per day, and the pulp going to the treatment vats contains 80 per cent minus 200-mesh, they assume that the tube-mills are grinding 80 tons per day, forgetting that with 16-mesh screens on the battery some 38 to 40 tons was already ground to 200-mesh before passing to the tubes, so that the latter are really grinding but 40 to 42 tons to the required mesh. In this connection we recall a neighboring operator who had 14 tube-mills under his direction, and had always estimated their work at 40 odd tons daily. On properly revising his estimates he found the figure reduced to about 28 tons daily. Feeling that the tube-mills were not doing as much as they should, he endeavored to improve the service. By loading the mills with additional pebbles, feeding the thickest pulp his launders would carry, and substituting 6-mesh screens on the batteries for 16-mesh, he brought the tonnage up from 650 to 1000 tons daily and still had 80 per cent minus 200-mesh solids in his final pulp. This mill follows the practice of open circuit; the pulp does not return to classifiers after passing through the tubes, but flows through a revolving trommel that removes any coarse sand that may accidentally occur in the pulp. The trommel has a 16-mesh screen.

A personal experience may be cited. We had 200 stamps, cone classifiers and thickeners, two tube-mills 5 ft. by 30 ft. and seven tube-mills 4 ft. by 22 ft. The ground pulp was again classified in cones. Following the dictum that the finer the sand going to the tubes the better the product, we used 35 and 40-mesh screens on the batteries, yielding a product containing about 60 per cent minus 200-mesh solids. From 730 to 750 tons could be treated, giving a final pulp of 80 per cent minus 200-mesh. By substituting 25-mesh screens on 100 stamps and 30 or 35-mesh on the other hundred, we were enabled to raise the tonnage to from 830 to 850 tons, but this was the most we could get through the tube-mills. With cone thickeners we had to give constant attention to keep the moisture down to 38 per cent.

We then hung up 100 stamps, put 8 and 10-mesh screens on the remaining hundred, rearranged and improved the cone system of classification and thickening, and added three tube-mills 5 ft. by 24 ft. This system enabled us to increase capacity to 1050 tons daily; while battery, crusher and conveyor costs that used to total 35 cents went down to 17 cents.

Some of the tube-mills received battery pulp only; others received a mixture of battery pulp and oversize returned from classifiers; and still others received only return feed. The last was itself classified or graded by the arrangement of the distributing box at the top of the elevator, so that some mills received fine returned sand and others coarse. We had continuous opportunity to observe the difference in grinding various sizes of sand. Coarse sand dewaters easily and grinds better in the tube-mill; fine sand is difficult to dewater in cones, and is harder to grind. With coarse feeds we could get lower moisture, greater tonnage and better ground pulp; with the finer feeds it was almost impossible to get low moisture, the tonnage was reduced, and the product never contained as much minus 200-mesh solids as was secured from the coarser feeds.

### Grinding Oxidized and Sulphide Ores

Our mill ore consisted of 950 tons of yellow, oxidized ore, assaying about $7 per ton, and 100 tons of blue, sulphide ore, assaying about $30 per ton. There was never much difference between the mine and mill superintendents regarding the tonnage or value of the yellow ore; but there was a continual difference between them as to the blue ore, as this factor entered strongly into the calculations at the end of the month. So we can safely assume that the figures for tonnage of blue ore, as agreed upon by the superintendents and given herewith, are correct.

Formerly the two classes of ore were mixed in the main bin, but on account of the more refractory character of the blue ore it was decided to give each separate treatment.[1] Ten stamps were set aside for blue ore, and a special bin provided. Separate classifying and thickening cones also were added. Later a drag classifier was substituted for the cones. The tube-mill was 4 ft. by 22 ft. and had a discharge opening about 18 inches in diameter, being of the tire type.

Extensive experiments were conducted on kind and size of pebble load, and on moisture content of pulp, each experiment being under way for a number of days with the regular attendants on shift. Battery screens were 7, 8, 10 or 12-mesh and were varied to give the desired tonnages under different conditions.

With iron pebbles or grinders, cast-iron ovals or old bolts cut into five-inch lengths, it was possible to grind 120 tons of blue ore daily and get a final pulp containing from 86 to 88 per cent minus 200-mesh. The moisture was carried as low as 25 per cent, though at this consistency the pulp was really too thick to work through the mill, and only about 100 tons could be handled. At 28 to 29 per cent moisture, however, 120 tons could be treated—that is, a total of 120 tons through stamps and tube-mill. From 30 to 35 per cent minus 200-mesh solids was produced in the batteries, leaving only about 70 tons actually ground to minus 200-mesh in the tube-mill. The power requirement under these conditions was about 95 hp., and as only a 75-hp. motor was available, a run of a few days only was possible.

With a mixture of iron grinders and imported pebbles, or using mine rock for pebbles, the horse-power was reduced to 80 or 85, and the total tonnage treated to 100, still obtaining a final pulp with over 85 per cent minus 200-mesh solids.

The final conclusion was to treat 80 to 85 tons of blue ore daily, using mainly mine rock for grinders, with a small daily addition of imported pebbles. The moisture was maintained at 31 to 32 per cent.

### Summary and Comparison of Results

While using 200 stamps with 25 and 35-mesh screens on the batteries, from 50 to 55 per cent of the battery pulp was minus 200-mesh, and the final tube-mill pulp contained 80 per cent minus 200-mesh. Under these conditions each of nine tube-mills ground on an average 25 tons to minus 200-mesh. Since using only 100 stamps, with 8 to 10-mesh screen on the batteries, giving a battery pulp containing only 30 to 33 per cent minus 200-mesh, each of twelve tube-mills averages 42 tons net. Drag classifiers have now been installed throughout the mill and the cones are on the scrap heap, as also is 38 (and so many decimals) per cent moisture for tube-mill feed.

Of these tube-mills, four were trunnion type with small discharge openings; eight were tire type with about 18-in. discharge openings. There were two pairs of 4 ft. by 22 ft. tubes, each pair comprising one trunnion type and one tire type. There was one pair of trunnion type only. The remaining mills, two 5 ft. by 30 ft., and one 4 ft. by 22 ft., all were of tire type with 18-in. discharge openings. With the first two pairs mentioned, it was quite convenient to compare the work of each type, and it was observed that the trunnion type never gave as good results in either quantity or quality as did the tire type.

### Effect of Speed in Grinding

Grinding in tube-mills is done by the pebbles sliding or rubbing over or against one another, and not by falling against each other. Very little grinding is done between pebbles and the tube-mill liner. The revolution of the mill should be so regulated that centrifugal force will raise the load high enough to permit the pebbles to slide over each other, but it should never be sufficient to permit the pebbles to fall through clear space. The proper mean speed probably results in letting some of the upper pebbles fall clear while the main body slides. This result can be obtained better through centrifugal force than by liners adapted to carry the whole load up.

---

[1] The blue pulp was agitated separately and then combined with the yellow, receiving also the agitation considered necessary for the latter. This method of treatment is an example of the practice which I suggested in a former article in this Journal, October, 1911, page 6[illegible]1, wherein I proposed giving the most refractory part of an ore its due treatment apart from the rest, instead of subjecting the whole ore to the treatment necessary for only a small portion of it.

Irregular-shaped mine rock used for grinding probably does little work until it has been ground to round or oval shape, and tube-mill power for this purpose is expensive. The same amount of power expended on grinding with round pebbles would accomplish much useful work. Feeding pebbles through the scoop is slow work, and pebbles that miss the scoop and fall in the feed-box may cause the breaking of the scoop. On removing the door of a tube-mill we usually find the pebbles evenly arranged throughout the mill, according to size, regardless of the method of feeding them.

When a tube-mill is grinding its full load a distinct rise in temperature of the shell can be noted. If the pebble load is light, or the moisture content of the pulp so high that the increased temperature is not apparent, the mill is not doing the work it can be made to do.

### Relining a Tube-Mill

With El Oro liners a tube-mill can be relined in 14 to 16 hours. The new liners should be piled near the tube on the previous day. At 5 a. m. stop the mill, take off the man-hole plates and start the mill again, allowing the pebbles to discharge on the floor, then stop the mill again, loosen the bolts holding the liners, taking the nuts off and driving the bolts to the inside, where they are gathered up. Now start the mill again, and inside of half an hour the plates will have fallen and almost all of them will be lying on the floor beneath the mill. The new plates and pebbles can be replaced, and the mill be in operation again by 8 p. m.

Denver, Colo.

## Copper in Babbitt Metal

BY E. W. HAGMAIER

Babbitt metals contain copper in varying amounts from several per cent to a trace. While copper is not the most difficult metal to determine in the alloy, still the steps necessary to obtain the copper in suitable form are somewhat tedious.

The writer has met with very good success by using the following scheme.

Place 1 gram of the filings or sawings in a 250-c.c. beaker, add 15 c.c. of hot water, and sufficient tartaric acid to hold all the tin and antimony in solution, run in 5 c.c. of nitric acid from a pipette and boil until the alloy is all dissolved. If the solution is milky in appearance, there has not been sufficient tartaric acid added, and the determination must be started over, with more tartaric acid. When solution is complete remove the beaker from the plate, cool, and add 5 c.c. of sulphuric acid, place on the plate and boil until all the nitric acid is driven off. This can be determined when no more brown fumes are expelled. This will require about five minutes boiling. As soon as the nitric acid is driven off remove from the plate or the tartaric acid will char. Cool, add 50 c.c. of water, allow the lead sulphate to settle and filter, washing with 2 per cent sulphuric acid solution. Several washings can be made by decantation before transferring the bulk of the precipitate to the paper. This precipitate can be used to determine the lead by dissolving off the paper with ammonium acetate and acetic acid and precipitating the lead as chromate. The filtrate from the lead sulphate is made up to 400-500 c.c., 1 or 2 c.c. of hydrochloric acid added, a strip of copper free aluminium added, and the beaker placed on the back of the plate, and the copper will be thrown out. With careful manipulation all of the copper can be thrown out in this way after which it can be filtered off and determined electrolytically or by titration.

Babcock-Hagmaier Laboratories,
Lackawanna, N. Y.

## Report of the Chemical and Dyestuff Committee of the New York Section of the American Chemical Society

At the meeting of the New York section of the American Chemical Society on Nov. 6 the Chemical and Dyestuff Committee, appointed at the preceding meeting, made its formal report.

The report was presented by the committee's chairman, Dr. BERNHARD C. HESSE, the other members of the committee being Messrs. J. B. F. HERRESHOFF, H. A. METZ, I. F. STONE, D. W. JAYNE, J. MERRITT MATTHEWS and ALLEN ROGERS.

On motion of Mr. Thomas J. Parker, the report was unanimously adopted. In the discussion Dr. L. H. Baekeland pointed out that time is needed to bring about an extension of the American chemical industries and that the success of an American coal-tar industry required the creation of a home market for its by-products.

In view of the authoritative character of the report we herewith give it in full:

### Committee's Report

*To the New York Section, American Chemical Society:*

At the meeting on Oct. 9, 1914, the chairman of this section was authorized to appoint a committee to investigate into the feasibility of expanding the chemical and dyestuff industry in the United States and to report to this section on Nov. 6, 1914.

The undersigned committee was appointed Oct. 15 and at once proceeded. It addressed letters of invitation to co-operate to those who have been most active in the public prints in urging expanding of the chemical, and particularly the dyestuff, industry in the United States; further, an invitation was extended to the maker of the motion, which resulted in the appointment of this committee. The assistance from these is nil.

A request was addressed to trade publications in the city of New York and to some of the metropolitan dailies; in all nine such publications were requested to publish a suggested notice for the purpose of inviting co-operation; the object of this committee was set forth and request was made that suggestions be mailed to the chairman of this committee. All but one of these publications have complied with that request. No help has been obtained by this committee from any suggestions mailed to it as a result of this publicity.

Your committee has carefully considered all the public suggestions as to methods of improvement and has searched through the governmental regulations of the belligerent nations as to embargo and as to contraband of war, in order to construct therefrom a list of chemicals, inclusive of dyestuffs, which have thereby been shut off from the United States, in the hope of thus being placed in a position to make specific recommendations of value.

### General Conditions of American Chemical Industries

It can be fairly stated that, in general, the chemical industry of this country is efficiently exploited and is making full use of all the opportunities presented to it under the normal conditions existing prior to the state of hostilities. Some of the chemicals which are imported from abroad are made in considerable amounts in this country as well, and the amount imported under normal conditions depends upon the ordinary normal fluctuations of business conditions both here and abroad. With the stoppage of this foreign supply the domestic production was not at once capable of making up the deficiency, but in a number of instances the American manufacturers have taken steps to increase their capacity, and the strain in the market of those particular things will exist no longer than it will require to extend the manufacturing facilities to the proper extent.

Among these are ammonia salts, barium chloride, barium nitrate, bleaching powder, sodium cyanide, yellow prussiate, sodium nitrite, sodium hydrosulfite, zinc dust.

If, however, it be desired and if public necessity requires the introduction of the manufacture of explosives and further chemicals and dyestuffs into our home industry, such as *coal-tar product explosives, pharmaceuticals, medicinals and other intermediates and finished coal-tar dyes*, then alterations of our tariff law are inevitable, and the consumers in the first place and the public in general must share in the burden thus imposed. If conditions of national defense in case of attack by a foreign power require us to manufacture our own explosives, and to be in that regard independent of all foreign nations at all times, or if our textile industries or any other of our industries requiring coal-tar chemicals, such as dyestuffs, shall forever be protected and made independent of foreign nations for the supply of those materials, then the nation as a whole must bear the burden incident to such expansion. Under existing circumstances private enterprise and private capital have gone their limit. They have reached the limit for two reasons:

I. The explosive, dye and similar industries abroad, just referred to, are in a state of high development and of refined organization, and are financially the best suited to carry on an offensive campaign against any nation attempting to take business away from them.

II. Domestic manufacturers are prohibited by law from making use of co-operative commercial devices, such as pools, trusts, manufacturing and selling agreements and the like, whereas such devices are wholly lawful abroad, and are encouraged by the respective governments. In other words, the American chemical industry is expected to cope with the foreign industry while both its own arms are tied behind its back and its opponents have full and free use of their arms.

### An Anti-Dumping Clause Required

The remedies required would be an effective anti-dumping clause that would certainly prevent underselling of domestic manufacturers in the United States by unfair methods. What the form of such clause shall be is a problem with which your committee is unable to cope; it is strictly a law-making and law-enforcing problem, and is allied to the usual problem of determining undervaluation as heretofore carried on by our Treasury Department; it, however, is a much more refined problem than the older problem of proving undervaluation. Nevertheless, your committee believes that with such a mechanism in our law that much would be done toward encouraging our chemical industries.

### Change in Tariff Law Required

According to the best information that your committee can gather, such an anti-dumping clause alone would not be sufficient, however, to create complete and independent domestic coal-tar explosives, dyestuffs and medicinals industries. It has been conclusively demonstrated during the past thirty years that the present tariff rate of 30 per cent on dyestuffs is not sufficient to induce the domestic dyestuff industry to expand at a rate comparable with the consumption of dyestuffs in this country, and that therefore all dyestuffs made from coal tar, whether they be aniline dyes or alizarin, or alizarin dyes, or anthracene dyes or indigo, so long as they are made in whole or in part from products of or obtainable from coal tar, should all be assessed alike, namely, 30 per cent ad valorem plus 7½ cents per pound specific, and that all manufactured products of or obtainable from coal tar, themselves not dyes or colors and not medicinal, shall be taxed 15 per cent ad valorem and 3¾ cents per pound specific.

The best information and judgment your committee can obtain is that the above manufactured products of coal tar, not dyes and not colors and not medicinal, should carry one-half the duty of the finished coal-tar dye and that the above rate of 30 per cent ad valorem and 7½ cents specific would probably be sufficient to encourage and enable domestic manufacturers to expand their operations to such an extent as to supply a very material increase in, if not the whole, of these commodities consumed in this country.

The reason for a specific duty is to protect the domestic manufacturer in the manufacture of the relatively cheap dyes, such as the cheap scarlets, the cheap yellows and the like, whose prices abroad are in the neighborhood of from 12 cents to 20 cents per pound, with dyes of that type 30 per cent ad valorem would not offer so serious an obstacle to importation and underselling thereof as does the 7½ cents per pound specific; on the other hand, on dyes whose prices are $1 and upward per pound the function of the 7½ cents specific more nearly approaches zero. That is, with the cheap dyes the chief function lies in the specific portion of the duty, and with the expensive dyes the chief function lies with the ad valorem portion of the duty.

This is said to be the price the nation will have to pay to have a complete self-contained and independent coal-tar chemical industry. However, it must be remembered that if such an industry be created and importation of coal-tar products, inclusive of intermediates and dyes, is restricted, its ultimate effect upon the Federal revenues will have to be considered. It will, therefore, be necessary to determine carefully if the advantages to be gained are equal to the price to be paid.

### No Compulsory Working Clause Required

This committee is a unit in the belief that an alteration of our patent laws aiming at compulsory working or compulsory licensing would not be any substantial benefit to this industry or to the country as a whole. Twenty-nine countries have attempted compulsory licensing clauses and fifty-six countries have attempted compulsory working clauses, and the best information your committee can obtain is that in none of these attempts has there been any appreciable measure of success. While it may be true that under extraordinary conditions, such as now exist, compulsory licensing might have some advantage, yet it is equally true that in normal times the disadvantage due to compulsory licensing or compulsory working would more than overbalance any advantage at all likely to be obtained under stress of unusual conditions.

In none of the countries where there have been working or licensing clauses, or both, co-extensive with the existence of the coal-tar chemical industry has there been established any real coal-tar chemical industry and your committee does not feel that an alteration in our present patent laws could be made which would be effective against foreigners and at the same time not be onerous and a hardship to domestic inventors. Your committee believes that in the long run and in the final outcome, our present system with regard to working and licensing is as efficient as that of any other country. In the dyestuff industry in particular there are so many non-patented commercial products and so many commercial products once patented now free from patent restraint that their production alone would from a basis for a very considerable industry, and your committee feels that the way to encourage that industry, if the establishment of that industry in this country be a national necessity, is through a change in the tariff and the additional anti-dumping feature in the administration of the tariff and not through any change in the patent laws.

Once established, such an industry could develop and ultimately cope with any foreign combination upon fair and equal terms. Over 90 per cent of the tonnage and of the individual dyes used in the United States will be free from any patent restraint within the next four years; over 75 per cent of the dyes are now in that condition.

### Availability of Raw Materials for Coal Tar Industry

The best information your committee has so far been able to gather is that this country can produce so-called coal-tar raw material in amounts sufficient for the needs of a complete domestic coal-tar chemical industry, inclusive of explosives and dyes, provided there is a certainty of outlet as to volume and continuity. Those engaged in manufacture here do not want to expand unless the dye users are willing to make corresponding contracts. In other words, it is a closed circle. If the dye users will contract sufficiently with the dye makers, the dye makers will contract with the coal-tar distillers and the industry will take a start. The initiative rests wholly with the users; if they cannot afford to contract the dye makers and the distillers cannot afford to make their contracts and additional investments.

### Coal Tar Products

*Benzol, toluol* and the like are produced in sufficient amount in present installations of by-product coke ovens to provide all of these things that would be needed for a coal-tar chemical industry of a magnitude sufficient to supply the United States market; the separation of these materials from the gas that carries them is dependent upon the market and the demand therefor. There is no inherent defect in our coke industry with regard to the actual making of these things; the only question involved is whether it be more profitable to burn the benzol, toluol and the like contained in the gas as a fuel than to separate them from each other for purposes of sale. Ample supply can be provided before any plant that could use benzol and the like for dyestuff making could be erected in the United States and thereafter the supply of these materials can readily be kept up to any requirements.

The materials of the preceding paragraph are the ones used in the coal-tar explosives industry, as well as in the coal-tar medicinals and dyestuffs industries. Each of these three industries co-operates with the others to make full use of those materials, alone none can fully make use thereof nor succeed; the correct and proper utilization of these materials requires successful co-existence of all three industries in one and the same country.

*Naphthalene* and *anthracene* are contained in the tars produced in the United States in an amount sufficient for the needs of a domestic dystuff industry, and it is merely a question whether it is more profitable to leave them in the creosote oil, where they now occur, or to separate them out of such oil and refine them for purposes of dye manufacture. Ample supply of either of them could be produced and provided at the same time or shortly after any plant could be erected in the United States for the use of these things in the production of dyes.

What has been said with regard to the supplies of naphthalene is also true of the supplies of *cresole*.

All the *creosote oil* contained in the total amount of coke-oven tar now made is separated from it and used. Increased production of creosote oil requires a greater production of tar, and a greater production of tar is dependent upon increased installation of recovery coke ovens.

*Phenol* or *carbolic acid* supply is primarily dependent upon our deliberately selected method of coal treatment; to change that treatment so as to get more phenol would entail abandonment of other advantages which would not be compensated for by the increased amount of phenol so produced. Under present circumstances freights and haulages play an important part. At isolated plants, separated by considerable distances from each other, small amounts of phenol are produced, and the separation of the phenol at such individual places would be economically unprofitable, and in order to concentrate this amount of phenol to or at a point where separation could be conducted profitably would entail freight haulages much in excess of the value of the phenol that would thus be transported.

The only source of *phenol* in sight is that produced synthetically from benzol by means of sulfonation and subsequent melting with caustic soda; this depends in turn upon our benzol supply, and would be profitable only so long as the United States market is not killed by the dumping of foreign phenol thereon, whether such phenol be synthetic or distilled.

*Salicylic* production depends upon availability of phenol, and the production of benzoic acid depends upon the availability of toluol, which has heretofore been discussed.

*Phthalic acid* made from naphthalene by means of bichromate cannot successfully compete with the mercury and sulphuric acid process, which is protected by patents having about three years more to run.

### Miscellaneous Chemicals and Raw Materials

*Acetic anhydride* can be made without trouble in this country, and will be made in this country as soon as the domestic demand is large enough and steady enough to warrant the installation of a suitable plant.

*Nitric Acid.*—All countries with the exception of possibly Norway and the countries importing from Norway are dependent upon Chile for the raw material for making nitric acid. It will not be profitable to make nitric acid from air in the United States until the value of the electric horse-power reaches a level of $3 or $4 a year, as it is in Norway.

*Ammonia* and its salts all depend upon recovery coke ovens, and such recovery plants are increasing as fast as circumstances will permit.

*Barium chloride* and other compounds of barium may be made from domestic barytes. A number of attemps have hitherto been made, but with indifferent success. Factories established within the last year promise to be successful.

*Magnesium chloride* of a sufficient purity to be used in the production of flooring is almost generally made from magnesite found in Greece, which is the only deposit known having sufficiently high purity; there are reports of suitable deposits in California and in Lower California, and with the completion of the Panama Canal the question of freights, which seems hitherto to have stood in the way of developing these deposits, may be eliminated. Other sources, less remote from centers of consumption, and using other materials, e.g., brine waste are about to be successfully operated.

*Manganese* in the form of pyrolusite is not known to occur in paying deposits in the United States; these are practically all in the Caucasus.

*Potash.*—In view of the great exertions that have been made for a number of years, both on the part of the Federal government through a number of its departments and a great many different groups of capitalists, there is nothing to be said in this report that would be of any value with regard to increased production of potash either as fertilizer or as a chemical.

*Yellow prussiate* and *sodium cyanide* can be and have been made from domestic materials in such an amount as to provide practically the entire consumption or a great portion thereof in this country so long as there was a sufficient duty on them; the present duty is not enough to protect the American manufacturer, and those who were engaged therein have in large measure withdrawn from the business, but some are reported to be taking up manufacture cautiously and in limited amount.

*Hydrosulphites* in solution can be made from domestic materials without interference with any patent rights; the production of solid salts and derivatives are, however, still protected by patents that have a few years more to run.

*Sodium nitrite* is produced more cheaply as a byproduct in Norway than it can be produced anywhere in the world; unless the price of the electric horsepower in this country sinks to a $3 or $4 level per year, as in Norway, this product cannot be manufactured in the United States.

*Oxalic acid* is and has been made to some extent in this country, and the information coming to your committee is that suitable efforts are being made to expand the capacity of existing plants.

*Tartaric Acid and Citric Acid.*—To make this country independent of others with respect to tartaic acid and citric acid would call for radical changes on the part of our grape growers and our lemon growers as to the policy of their business.

It is probably true that edible grapes do not produce argols (the crude material for tartaric acid) very largely, and that our domestic lemons do not produce as large yields of juice (the crude material for citric acid) nor as high an acidity as do the Italian lemons; therefore, an independent supply of the raw materials produced in the United States for tartaric and citric acids is, in the first instance, an agricultural problem, and, in the second instance, a market problem.

Finally, it should be pointed out that the United States is by no means the only country whose chemical and allied business has been strained or upset by the European war. Each and every other country has felt the strain. British committees have gone into the same subject of expanding British chemical industries, and not only that, but also into the question of making their very basic necessities, and the reports have so far been adverse to any immediate relief by domestic manufacture. The Boston Chamber of Commerce, through its committees, has arrived at the same conclusions for this country.

It is further clear that the stability of a complete domestic chemical industry, insofar as it depends upon foreign supplies, is bound up to a successful merchant marine and to an efficient foreign banking condition just as in all our foreign business.

### Findings and Conclusions

Your committee finds as follows, as to the facts:

I. Prior to the hostilities the domestic chemical industry was utilizing and exploiting every reasonable opportunity to its full extent.

II. Since the outbreak of hostilities domestic industry has increased its output just as fast as physical means could be provided and physical obstacles overcome.

III. Since the outbreak of hostilities domestic plants that had theretofore been shut down or partly dismantled because of disastrous foreign competition are said to have resumed operation, with caution.

IV. That a 30 per cent duty on some coal-tar dyes for over thirty years has not produced a real coal-tar dye industry in this country.

Your committee submits its conclusions as follows:

A. To prevent the unfair underselling alleged to be practiced by foreigners in this country, the adoption of an effective anti-dumping clause.

B. The so-called coal-tar "intermediates" which are the basis of the coal-tar chemical industry, inclusive of explosives, medicinals, and dyestuffs, should be assessed one-half of whatever the finished dyes are taxed for tariff purposes; all coal-tar dyes without exception to be taxed alike, namely, 30 per cent ad valorem and $7\frac{1}{2}$ cents per pound specific.

C. Changes in the patent laws such as by compulsory licensing or compulsory working clauses are wholly ineffective, do more harm than good, and should not be attempted.

Your committee recommends that this report be submitted to the appropriate committees of Congress. Further, that this report be forwarded to interested organizations.

Respectfully submitted,
BERNARD C. HESSE, *Chairman.*
J. B. F. HERRESHOFF.
H. A. METZ.
I. F. STONE.
D. W. JAYNE.
J. MERRITT MATTHEWS.
ALLEN ROGERS.

---

## Philadelphia Meeting of American Institute of Chemical Engineers

The seventh annual meeting of the American Institute of Chemical Engineers will be held in Philadelphia from Dec. 2 to 5, 1914. Hotel headquarters will be at the Hotel Adelphia.

Business meetings will be held at the Hotel Adelphia on Wednesday, Dec. 2, 10:30 a. m. and at the Franklin Institute on Friday, Dec. 4, 9 a. m. Sessions for the reading and discussion of papers are scheduled as follows:

Dec. 2, 11:15 a. m. (Hotel Adelphia):

D. D. Jackson, The manufacture and application of the artificial zeolites (permutite) in water softening.

Allerton S. Cushman and George W. Coggeshall, Feldspar as a possible source of American potash.

Dec. 2, 8:15 p. m. (Franklin Institute):

George O. Smith, Distribution of Industrial Opportunities.

Dec. 4, 10 a. m. (Franklin Institute):

John V. N. Dorr, Hydrometallurgical apparatus and its use in chemical engineering.

E. H. French and James R. Withrow, Hardwood distillation.

Jokichi Takamine, The chemical industries of Japan.

Bernhard C. Hesse, Need of up-to-date manufacturing statistics.

Dec. 4, 8:15 p. m. (University of Pennsylvania):

S. P. Sadtler and S. S. Sadtler, Ore flotation.

Edw. Gudeman, Aspects of some chemical industries in the United States.

Excursions will be made on Wednesday afternoon to the Atlantic Refining Company and United Gas Improvement Company, on Thursday (all day) to the Welsbach Company works in Gloucester, N. J., the New York Shipbuilding Company, and the Farr & Bailey Linoleum Works in Camden, N. J., on Friday afternoon to the Commercial Museums and the Laboratories of the University of Pennsylvania, and on Saturady to the Barrett Manufacturing Company in Frankford, Philadelphia. A subscription dinner will be held on the evening of Thursday at the Hotel Adelphia.

# Chloridizing Ores at Silver City, Utah.

*(Editorial Correspondence)*

Interest in the revival of chloridizing processes in Utah has centered mainly in the work of N. C. Christensen, Jr., at Silver City, and Theodore P. Holt and George H. Dern, at Park City. Former issues of METALLURGICAL AND CHEMICAL ENGINEERING[1] have made frequent reference to these developments, and one issue[2] described the Park City process in detail. The principles underlying the work of Mr. Christensen at Silver City are similar to those applied at Park City, but the method of application is quite different as will appear from the following notes.

### The Knight-Christensen Metallurgical Co.

The mill at Silver City, Utah, shown in Fig. 1, was erected primarily for the local treatment of ore from the mines of Mr. Jesse Knight, who has been deeply interested in the development of a metallurgical process and has given commendable financial support to the ideas of Mr. Christensen. The ores from the Knight mines afforded an excellent variety of oxidized, sulphide and silicious material from which to make a mixture most suitable to the process of treatment. Silver is the metal of principal value; copper, gold and lead also occur, and are of importance in about the order named. In metal contents the different ores range from 4 to 30 oz. silver and 0.03 to 0.20 oz. gold per ton, 1 to 8 per cent lead, and from a trace of 1.75 per cent copper.

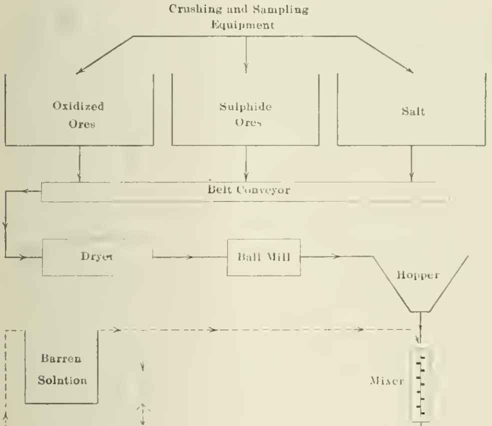


FIG. 1.—ORE-TREATMENT DIAGRAM, KNIGHT-CHRISTENSEN MILL

The sulphides provide the fuel necessary in the chloridizing roast, and in this respect the metallurgical conditions differ from those in the plant at Park City where coal is added to the ore-mixture before roasting. Otherwise the process is similar except in method of application. Briefly, it consists in roasting a mixture of ores and salt; condensing the acid roaster gases in salt solution; leaching the roasted ore with this solution, and precipitating the metals successively—gold and silver on copper, copper on lead, and electrolyzing the final lead solution. The diagram in Fig. 1 presents the main features of the process.

### Preparation of the Ore-Mixture

The crushing and sampling department comprises the usual machinery for such purposes and affords accurate samples of ore received from the different mines. Ores and salt are both crushed to $\frac{3}{8}$-in. before delivery to their respective storage bins. Adjustable mechanical feeders deliver fixed quantities of the different ores and salt onto a belt conveyor that feeds the dryer. An effort is made to maintain about 4 per cent of pyrite in the mixture, and salt is added to the extent of 8 to 10 per cent. Salt costs $4.15 per ton at the mill.

From the dryer the mixture is passed to the ball mill, shown in Fig. 2, where it is ground to the requisite degree of fineness. This ranges from 8 to 20-mesh and depends on the character of the ore under treatment. It is recognized that inasmuch as sulphides are used for fuel, the finer they are ground the more uniform their distribution through the mixture, with consequent reduction in quantity required and improvement of the chloridizing roast. Compact, silicious ores require finer grinding than do the more porous oxidized iron ores. Salt, of course, becomes thoroughly disseminated through the mass in the process of grinding.

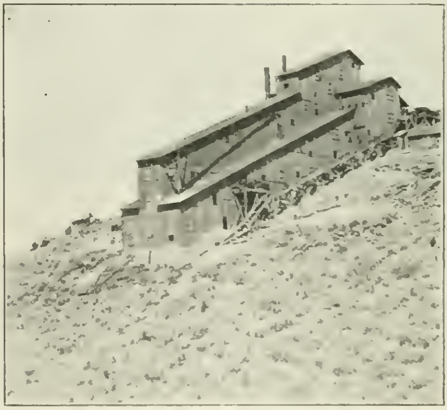


FIG. 2.—KNIGHT-CHRISTENSEN MILL, SILVER CITY, UTAH

The next step is the addition of 8 to 10 per cent of barren mill solution to the ore-mixture. It is essential that this moisture be uniformly distributed throughout the mass in order that the physical condition of the ore-bed on the furnace hearth shall be the same at all points. A simple and effective mixing device has been constructed, consisting of a vertical pipe 4 ft. long and 6 in. in diameter, within which is mounted a central revoluble shaft provided with horizontally projecting teeth arranged at intervals along its length. The shaft rests in a step-bearing and makes 480 r.p.m. Ore and solution are fed at the top of the pipe, and a uniformly moist, porous mixture is delivered at the bottom. Several mixing devices had been tried prior to the adoption of this one, but none gave satisfaction.

---

[1] This journal, Nov., 1913, pp. 605 and 657; April, 1914, p. 222; Oct., 1914, p. 658.

[2] Chlorination at Park City, Utah, this journal, July and August, 1914, pp. 431 and 492, respectively.

### Chloridizing-Roasting

The roasting furnace consists essentially of a horizontal, annular, revolving, perforated hearth, 22 ft. outside and 10 ft. inside diameter. A feed hopper is erected at one point over the hearth, and adjacent to it on either side is the ignition box and the discharging device. The hearth is constantly under downward suction from a fan placed at one side of the furnace. A roaster of this size operating under the conditions existing at Silver City has a capacity of 300 tons in 24 hours.

In operation, the hearth makes one revolution in 40 minutes. The ore is fed onto the hearth continuously in a loose, porous layer from 4 to 8 in. deep, according to the fineness of the mixture. Finely crushed ores are deposited in shallow beds. The grates have perforations ⅛ in. by 1 in. Ignition of the charge is started as it passes under the oil-fired furnace and is continued by the down draft throughout the revolution of the hearth to the point of discharge. Careful adjustment of the temperature is required to get uniform ignition and prevent sintering the ore, and the fire-box is kept at a dull red heat with an oxidizing atmosphere. The temperature of the roast is about 700 deg. C. It can run as low as 500 deg., but may not exceed 800 deg. without danger of loss by volatilization. Oil consumption varies with the depth of the bed and fineness of the ore, and ranges from ½ to 1 gallon per ton. The cost of oil, crude distillate, is about ten cents per gallon in tank-car lots.

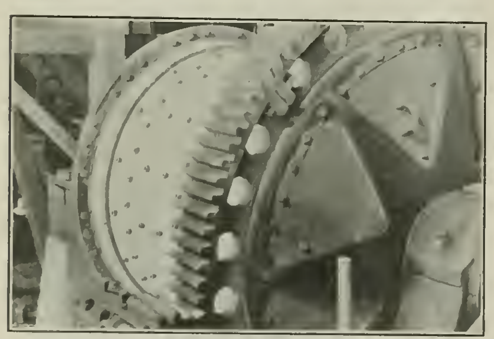


FIG. 3.—BALL MILL, KNIGHT-CHRISTENSEN MILL

The roast is loosened and detached from the hearth by a plow that extends nearly to the hearth surface. A screw conveyor engages the loose mass and removes it. A view of this mechanism is given in Fig. 3, which shows also a part of the annular hearth and the feed hopper. In order to provide a layer of coarse material on the hearth beneath the raw charge, to protect the grate from corrosion and prevent fine ore running through the perforations, a portion of the roasted ore is allowed to pass over the plow and fall onto the hearth just before passing under the feed hopper. The chloridized ore is still hot when removed from the roaster. It is elevated to a storage hopper where chloridization continues until such time as the ore is withdrawn and charged into the leaching barrels.

As the ore-bed is constantly under diminished pressure, no chlorine or other fumes contaminate the mill atmosphere. A steel fan driven by a 15-hp motor draws the fumes from beneath the hearth and forces them into wooden towers containing horizontal wooden partitions through which barren mill solution is descending. Emerging from the towers the solution contains $SO_2$, Cl, and about 2½ per cent HCl, and is almost at boilin gtemperature. This is the active leaching solution with which the chloridized ore is treated. Of course, the solution gradually becomes saturated with salt as it circulates through the leaching barrels.

### Metals Go Into Solution Rapidly

Ore and solution are both hot when they are brought together in the leaching barrels, and conditions are most favorable for rapid solution of the chloridized metals. The barrels are spherical in shape, mounted on trunnions, and contain filter-bottoms. A charge consists of five tons of ore, and solution in the ratio of 2½ to 1 of ore. When a barrel is full it is allowed to stand for about 10 or 15 minutes before percolation commences. The pregnant solution flows to the precipitating department. After about 2½ hours of percolation the charge receives a water-wash for ½ hour, after which the tailing is discharged by rotating the barrel.

The amount of wash water used is only sufficient to counterbalance the loss of that quantity of mill solution used to moisten the ore, plus that evaporated from the towers and tanks. As the metals go into solution very rapidly they are removed from the gangue early in the period of percolation. The solution applied toward the end of the period is practically a barren wash, and the final wash with water serves mainly to recover salt. Enough water remains with the tailing to make it flow like thick molasses when discharged from the barrels. No fouling of solution takes place, as it is renewed practically every day. Iron does not go into solution to any great extent, and even when treating oxidized ores high in iron the pregnant solution will contain but 0.1 per cent of that metal.

If much gold is present in the ore it is considered necessary to have the mill solution stronger in chlorine, and that element must be added in some form or other. Manganese dioxide existing naturally in the ore, or added as a constituent of the roaster feed, would generate chlorine by reaction with the chlorides present.

### Precipitation on Metals and by Electrolysis

The gold, silver and copper in the pregnant solution are precipitated successively on more electro-positive metals—silver and gold on copper, and copper on lead. The final lead solution is electrolyzed under high current density. Precipitation is accomplished in revolving wooden drums, or wood-lined trommels, containing the necessary metals in the form of small spheres. The metal precipitated in one drum is removed by settlement or filtration before the solution flows to the next drum. This method of precipitation is continuous, rapid and highly efficient, as the solution is warm and the surface of the precipitating metal is constantly kept clean by abrasion. The electrolysis of the lead solution yields a spongy product which is made compact by rolling before it is melted. The acid gases from electrolysis are conducted to the towers where, together with the roaster gases, they are absorbed in the barren mill solution that comes from the precipitation department.

The metallic products are high grade, and after melting are ready for market. Some of the copper and lead can be converted into suitable forms for precipitating purposes, and the accumulating balance can be disposed of in the market.

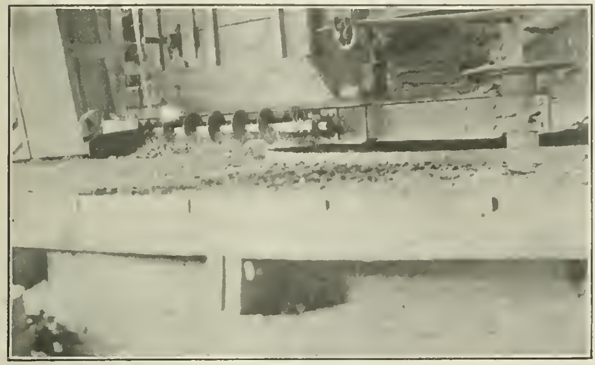


FIG. 4—CHLORIDIZING FURNACE, KNIGHT-CHRISTENSEN MILL

Wooden pipes and rubber hose are used for the transportation of the mill solution. There are no valves and no pumps in the system. All elevating of solution is done by means of wooden montejus. Porcelain pumps could be used successfully under a low head, and probably would be adopted in a new plant. Some porcelain pipe also could be used to advantage, as wooden pipe does not swell under the action of salt solution as with water, and is likely to permit some leakage.

While this mill of the Knight-Christensen Metallurgical Co. is regarded as an experimental plant on a large scale, nevertheless its sponsors are satisfied that they have demonstrated a process that will be profitable. Another mill employing the same methods and apparatus is expected to be in operation in the Park City district in the near future, and we hope later to present some data thereon.

---

## The Effects of Pickling Upon the Corrosion of Iron

BY E. A. RICHARDSON

In connection with a test that was to be made upon the corrosion of sheet iron, the question arose as to how the surfaces should be cleaned. Since a number of methods could be used, it was necessary to know what effect these different methods would have on the subsequent corrosion. A small preliminary test of short duration was, therefore, made to determine the best method for cleaning the specimens to be used in the larger test.

In much of the literature that deals with the corrosion of iron and steel, little mention is made of the method of preparing the samples for test, that is, little attention seems to have been given to the means of eliminating the effects of scale on the specimens of sheet metal and in particular to the effect produced when this scale is removed by pickling.

It is the object of this article to show that for short time tests the effect of pickling exerts a great influence upon the rate of corrosion, and that tests in which this effect is not eliminated are not comparable and may even be unreliable and misleading.

This conclusion is based upon the results of a test made upon four kinds of commercial sheet irons. The samples tested were 16 gauge in thickness and 4 in. square. In order that they might be comparable before pickling, they were annealed in a muffle furnace at the same time at a temperature of 750 deg. C. and cooled slowly.

The samples were pickled as follows:

(1) Scale removed by grinding on an emery wheel,
(2) Scale removed by pickling in sulphuric acid,
(3) Scale removed by pickling in sulphuric acid, and the samples washed in water and dipped in dilute nitric acid.
(4) Scale removed with sulphuric acid and the samples washed with water and dipped in a mixture of ammonia water and hydrogen peroxide.

After pickling, the test pieces were washed thoroughly with water and dried by dipping in alcohol. They were then measured and weighed and exposed to the weather in a wooden rack from October 1 to January 1.

The four materials used analyzed as follows:

| Sample | Sulphur | Phosphorus | Carbon | Manganese | Copper |
|---|---|---|---|---|---|
| a | 0.020 | 0.003 | 0.01 | 0.052 | 0.048 |
| b | 0.059 | 0.117 | 0.10 | 0.319 | 0.268 |
| c | 0.045 | 0.094 | 0.10 | 0.406 | Trace |
| d | 0.051 | 0.009 | 0.035 | 0.044 | 0.044 |

It was noticed at once that the method of pickling had a decided influence upon the starting of corrosion. The samples which had been dipped in nitric acid were the last to start rusting; in fact they were rained upon several times before any signs of rusting appeared. The others started to rust after the first rain.

The duration of this test was ninety-five days, after which the samples were examined before removing from the rack, the examination being made by three independent observers. All three agreed to the same classification, which was as follows:

First. Sample "b." This material was by far the best. The rust was red in color and adherent and was smooth and fine grained.

Second and Third. Samples "a" and "d." These materials were corroded about equally. The rust was coarse-grained and was becoming loose.

Fourth. Sample "c." This material was much the worst. The rust was yellow in color, was coarse-grained and very loose.

After cleaning the surface of the samples with neutral ammonium citrate solution, the same three observers again observed them. The results were as before.

After these inspections the samples were reweighed and the loss in weight computed in grains per square centimeter. The results are as follows, each figure being an average of two:

METHOD OF CLEANING SURFACE

| Sample | Grinding | Sulphuric acid | Sulphuric and nitric acids | Sulphuric acid and ammonia and peroxide |
|---|---|---|---|---|
| b | 0.0372 | 0.0420 | 0.0293 | 0.0389 |
| a | 0.0597 | 0.0600 | 0.0441 | 0.0512 |
| d | 0.0651 | 0.0463 | 0.0497 | 0.0476 |
| c | 0.0952 | 0.0967 | 0.0646 | 0.0864 |

From an examination of the above figures it is evident that the method of cleaning the surface of test pieces before exposure has a decided influence upon the rate of corrosion. This is particularly noticeable when a passifying agent such as nitric acid is used. Upon long exposure tests this effect would undoubtedly be decreased and might perhaps be eliminated.

The author acknowledges several suggestions made by Mr. L. T. Richardson during the progress of this test.

Warren, Ohio.

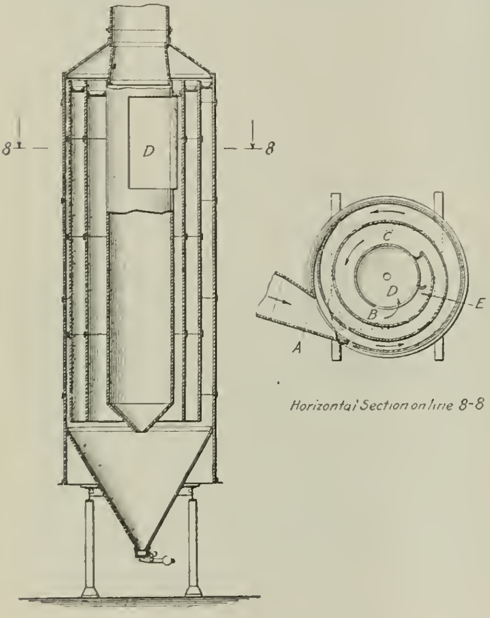
# The Gas from Blast Furnaces, Its Cleaning and Utilization

BY J. E. JOHNSON, JR.

(Concluded from p. 692.)

### PRIMARY WET CLEANING

For primary cleaning, in Europe in particular, a separation of the dust by the use of water has been preferred for many years to a dry separation, on account of the very much greater efficiency obtained in cleaning, and on account of the importance of reducing the water vapor contents of the gas to a minimum, thus allowing more efficient combustion. The cooling and washing of the gas are usually performed simultaneously, sufficient water being used to reduce the temperature of the outgoing gases to practically the temperature of the incoming wash water. Experience has shown that cooling the gas in this manner, to allow condensation and separation of the water vapor, causes less attendant loss of heating efficiency than prevails in heating with vapor-laden gas.



FIGS. 11 AND 12—DYBLIE WHIRLER

### ZSCHOCKE SYSTEM

Zschocke washers have been used almost entirely in Germany for wet primary cleaning. These consist of cylindrical or square steel towers fitted with a series of wooden grids or hurdles placed at suitable intervals within the apparatus. These hurdles are arranged in such a manner that the water, which is sprayed in at the top of the tower, is broken up into very fine streams, which drip down between the grids and meet the gas coming up, the gas being introduced at the bottom of the tower. The intimate contact so obtained wets down the dust, which is carried with the water to the bottom. These Zschocke towers are usually water-sealed and cone-shaped at the bottom, and the latest type has a siphon arrangement; in either case, the dust is readily removed from the bottom of the apparatus.

Zschocke towers have been found sufficient to cool and clean the gas to the proper degree for use in hot-blast stoves, under boilers, and for similar purposes. A fan washer, into which water is introduced, is frequently used as an auxiliary to the Zschoke towers for primary cleaning, especially when the scrubbing capacity of the towers is small.

A water separator, equipped with internal baffles, is usually located beyond the washer to allow separation of the entrained water.

Zschocke washers are used considerably in the United States, and some additional systems have also been developed here for the wet separation of dust; for instance, the Duquesne spray tower and the Steinbart spray tower. The basic principle of these spray towers consists of the creation of a rain or spray by means of suitably arranged nozzles, and the gas is cleaned and cooled in passing through this spray.

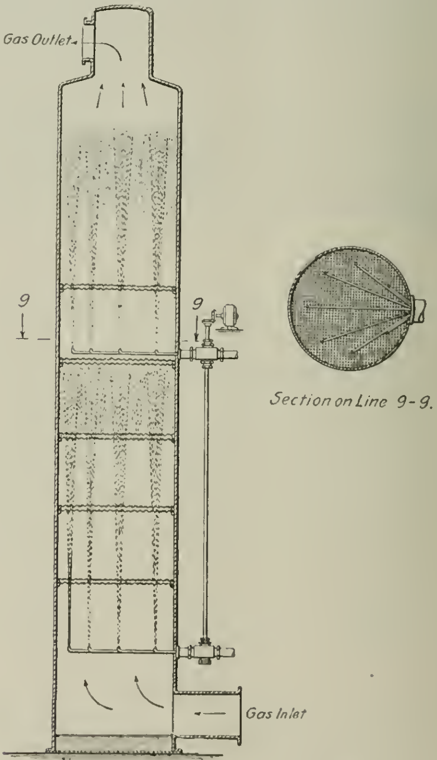


FIG. 13—DUQUESNE SPRAY TOWER

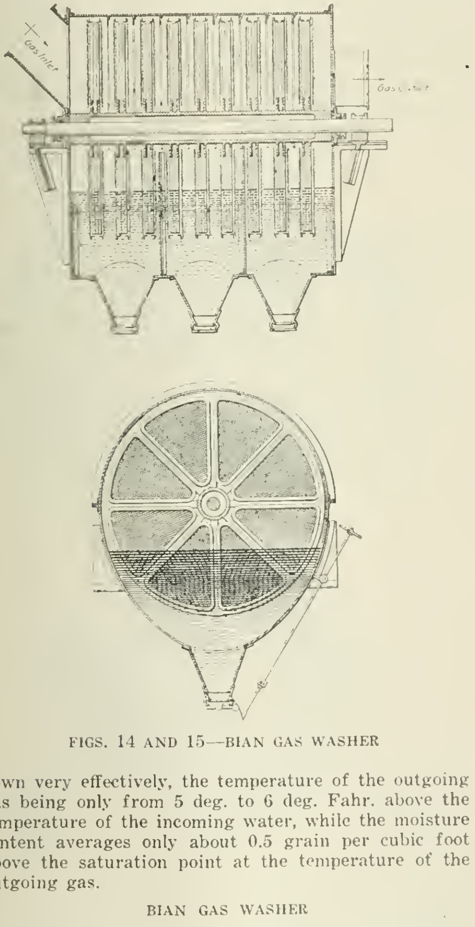
### DUQUESNE SPRAY TOWER

The Duquesne tower consists of a shell about 80 ft. high by 12 ft. in diameter. As shown in Fig. 13, the tower contains five sets of double screens, the sets being spaced 6 ft. 10 in. apart. Under the first set of screens are distributed seven nozzles, the feed water for which is controlled by a valve outside the tower. Under the fifth set of screens, seven similar nozzles, also controlled by a valve outside the tower, are distributed, just above the range of the lower nozzles.

The controlling valves have a revolving core which successively blocks off the openings to the different nozzles, thereby temporarily stopping the flow of water and creating an area of low pressure directly above the nozzle. When the core has passed, the flow of water resumes through this nozzle and sprays the gas which has reached this point. The core is revolved electrically, at the rate of about 15 revolutions per minute, and a 5-hp motor is ample to operate four valves, which are sufficient for two towers.

The screens, which are placed above the nozzles, break up the water into fine drops, permitting intimate contact of the gas and the water.

In the operation of these towers at Duquesne, the gas rises through the scrubber at the rate of 4 ft. per second, and the water at the rate of 60 ft. per second with a head of 35 lb. main pressure. The gas is cooled down very effectively, the temperature of the outgoing gas being only from 5 deg. to 6 deg. Fahr. above the temperature of the incoming water, while the moisture content averages only about 0.5 grain per cubic foot above the saturation point at the temperature of the outgoing gas.



FIGS. 14 AND 15—BIAN GAS WASHER

### BIAN GAS WASHER

The Bian gas washer, as shown in Figs. 14 and 15, consists of a stationary horizontal steel cylinder through which the gas passes from one end to the other. Inside the cylinder, there slowly revolves a shaft which carries a number of vertical disks consisting of wire netting of fine mesh. The diameter of these disks is very slightly less than the inside diameter of the cylinder, and this arrangement necessitates the gas passing through the openings in the screens as it travels through the apparatus. The screens, to the extent of nearly half their diameter, dip into water contained in a trough upon which the open bottom of the cylinder rests, and as the shaft revolves, the part of the screens which has been immersed rises from the water with the meshes covered with thin films of water, thus allowing thorough contact with the gas as it passes through the perforations.

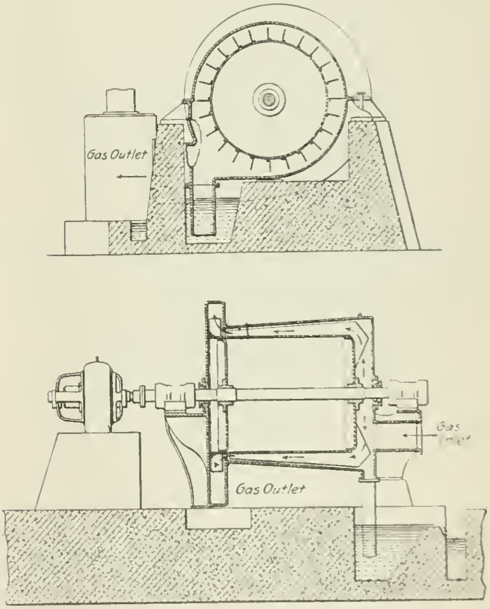
### FINAL WET CLEANING

(Some of these systems can also be applied to primary cleaning.)

The amount of cleaning accomplished in Zschocke and similar towers, and in the Bian washer, while satisfactory for stoves and boilers, was found to be not sufficient when the gas was destined for use in gas engines, and the systems of Theisen and Schiele were developed for this purpose.

### THEISEN GAS WASHER

The Theisen washer, as shown in Figs. 16 and 17, consists of a casing lined with a special wire netting, within which revolves at a high speed, a drum carrying numerous fan blades set at oblique angles to the axis of rotation, these blades or vanes being so fitted that they form a continuous spiral curve. This allows the gas to be drawn in at one end of the casing and expelled at the other end. Water is admitted at the side of the casing and is converted into a fine spray by the revolutions of the blades, and the spiral arrangement of these blades causes the spray to flow in the opposite direction to the gas, which passes through this spray, being simultaneously cleaned and cooled. The dirty water leaves the apparatus by a water seal at the bottom.



FIGS. 16 AND 17—THEISEN GAS WASHER

The Theisen and Schiele systems of final wet cleaning have for years given very satisfactory results, but are now being gradually superseded by systems requiring less capital expenditure and less operating expense. Most of these systems can be used for primary cleaning as well as for final cleaning, by installing in two stages. The most important of the wet cleaning systems which perform as efficient cleaning with the consumption of much less power and water than the Theisen and Schiele systems are the disintegrator system of Theisen, the disintegrator system of Schwarz-Bayer, the Fowler & Medley rotary washer, and the Feld rotary washer, while the Halberger-Beth dry cleaning system of filtration through canvas is remarkably efficient in cleaning and is cheap to operate. Following is a detailed description of each of the systems mentioned, together with several other modern systems:

### THEISEN DISINTEGRATOR GAS WASHER

There are two styles of Theisen disintegrator gas washers. One style consists of a casing in which the gas enters by two apertures at the base of the apparatus and is washed by a spray of water in a perforated drum or cage equipped with vanes, the drum revolving within a stationary drum, the gas being drawn through the apparatus by a fan mounted on the same shaft and discharged with the necessary pressure to carry it to the point of consumption. The second style also has the fan mounted on the shaft, but the fan is inclosed within the disintegrator.

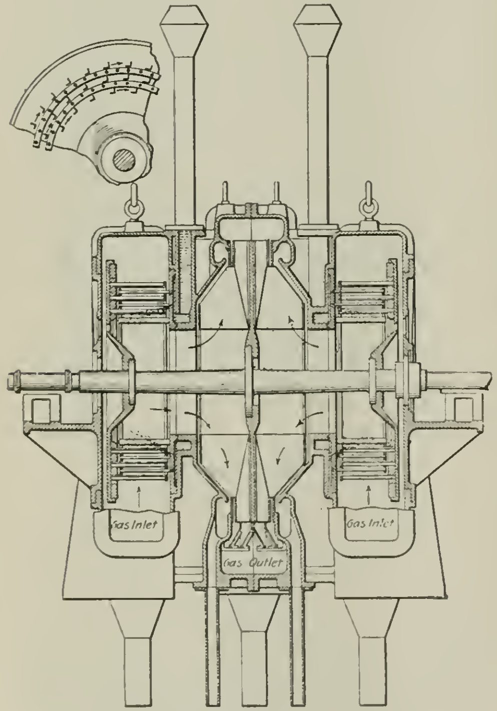


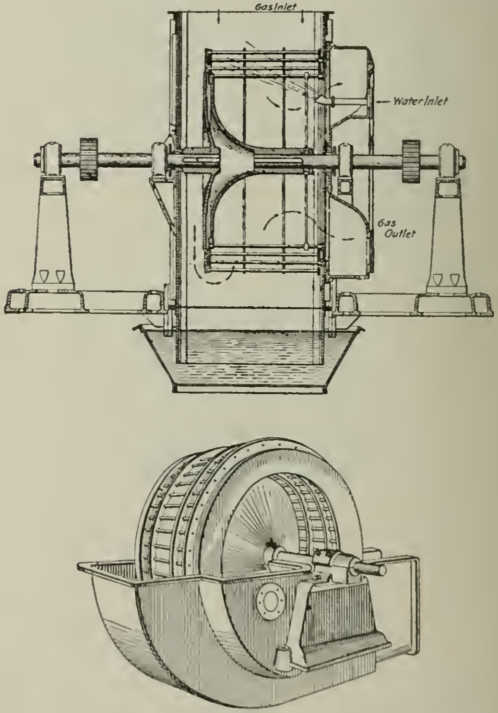
FIG. 18—THEISEN DISINTEGRATOR GAS WASHER

The Theisen disintegrator consists of a series of rotary and stationary perforated drums or cages arranged concentrically within one another, as shown in Fig. 18. The stationary drums consists of round bars and the revolving ones of angle bars. The hot raw gas enters the apparatus at the bottom, meets the effluent water and undergoes a preliminary cooling and cleaning in the lower part of the machine. The gas is drawn in counter-current through the series of rotary and stationary drums by means of a fan. The water is converted into a fine spray by the centrifugal action of the rotating drums, and the gas, passing through this spray, is cleaned. The fan is located in the same casing and on the same shaft as the rotary disintegrating drums, the shaft being direct motor driven. Fresh water is introduced into the innermost rotating drums in the form of a finely divided spray.

The cooling and cleaning of the gas and production of the pressure necessary to conduct the clean gas to its point of consumption are all performed in one apparatus and with one motor. It is stated that this disintegrator is an improvement over the former. Theisen apparatus, requiring much less power and water, and performing the necessary cleaning of the gas without preliminary towers.

### SCHWARZ-BAYER DISINTEGRATOR GAS WASHER

The Schwarz-Bayer system of gas cleaning makes use of the disintegrator principle, and its general arrangement is simple. The complete set of gas-cleaning apparatus consists of a disintegrator in connection with a saturating chamber in the form of a hood; then a fan placed immediately behind the disintegrator, and finally a water separator. In case both primary and final cleaning are desired, two such sets of apparatus are used, the second of which further cleans the gas which has been primarily cleaned in the first.



FIGS. 19 AND 20—SCHWARZ-BAYER DISINTEGRATOR GAS WASHER

The disintegrator, as shown in Figs. 19 and 20, consists substantially of two sets of steel pins, cold-riveted to two steel disks, which disks are set side by side and revolve in opposite directions. The pins of one revolving disk, which interlace with the pins of the other revolving disk, form with the water, through the effect of rotation and dripping, a fine spray or mist, which allows a thorough mixture of the water with the gas traveling among and between the pins before leaving the apparatus.

The gases from the blast furnace pass from the raw gas mains directly into the disintegrators without previously passing through Zschocke towers or similar preliminary washer or cooler. The gas enters through the top of the hood and passes toward the center of the disintegrator, while water is being introduced through the sides to the center. The hood acts to some extent as a pre-cleaner and cooler, as some of the spray from the disintegrators is thrown into the hood and there comes in contact with the hot gas and rapidly evaporates, simultaneously cooling the gas. By the revolution of the disintegrator the water is projected toward the periphery of the apparatus and is broken up into a fine spray; the gas mixes thoroughly with this water and is cooled, and most of the dust contained in the gas is precipitated. The gases pass through the disintegrator in a current counter to that of the water.

The application of the counter-current principle enables the gas to encounter cleaner and colder water in its passage through the disintegrator; hence it is better cleaned, and its temperature is reduced more nearly to the temperature of the entering cooling water. This principle has the effect of materially reducing the amount of water and power consumed. Each disk is direct driven by an individual motor and the speed is determined by the degree of cleanliness desired in the gas. The gas is drawn through the disintegrator by means of a fan located immediately behind the disintegrator apparatus, and passes from the fan to a water separator.

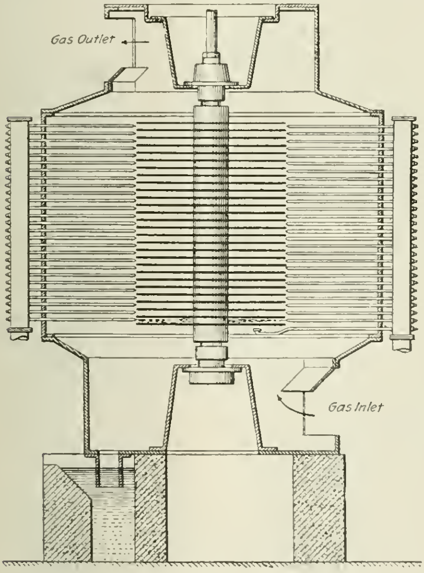


FIG. 21—FOWLER & MEDLEY VERTICAL GAS WASHER

The use of pins in this apparatus as a disintegrating medium allows the passage of the gas with very little resistance, and a consequent saving in power. There is also very little possibility of the dust settling on the pins and clogging up the apparatus.

### FOWLER & MEDLEY VERTICAL GAS WASHER

This apparatus, as shown in Fig. 21, consists of a circular cast-iron casing containing a revolving shaft running vertically through the middle. On this shaft are fixed a number of disks, made either of steel or of cast iron, depending upon whether the water used is alkaline or acid. Each disk is equipped with a collar separating it from the adjoining disks, and each collar is punched or drilled with six holes, through which six bolts pass vertically, thus holding all the disks in place. The shaft is direct driven with a vertical-spindle motor. Two fixed water sprays are provided for each disk, diametrically opposite each other, one on each side of the washer and projecting between each pair of disks. The jets of water, which are introduced through nozzles having about $\frac{1}{8}$-in. openings, enter with sufficient pressure to strike the collar between the disks, and, as the disks revolve, the water is thrown against the top and bottom of these disks and then against the outside wall of the casing, creating a fine spray or mist in the space between the outer edge of the disk and the wall of the casing, through which space the gas passes. The gas enters the washer at the bottom, passes through this spray or mist, and leaves clean at the top.

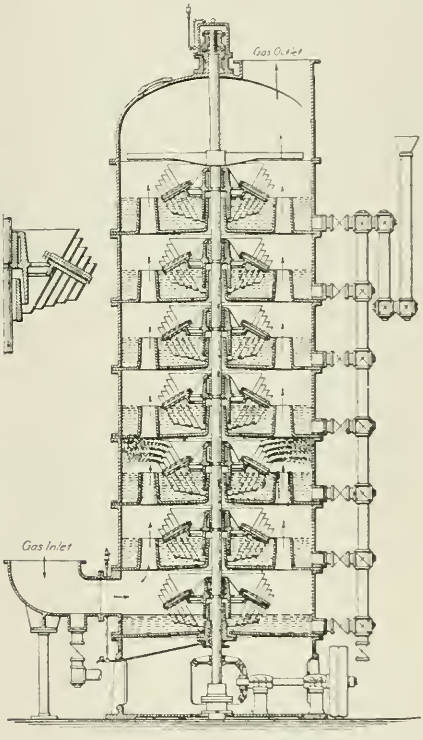


FIG. 22—FELD GAS WASHER

This washer can be used for either primary cleaning or final cleaning, or both; in case final cleaning is desired, two washers would be used in series, the first apparatus to clean the gas sufficiently for primary purposes and the second apparatus to finish the cleaning of the gas for gas-engine use.

### FELD GAS WASHER

The Feld washer, as shown in Fig. 22, consists of a series of superimposed sections, the bottom of each section being provided with ports for the passage of gas. The gas enters the bottom of the washer and passes from chamber to chamber to the top, whence it is led away. Each section or chamber is provided with a series of cones perforated at the top and mounted upon a cast-iron spider, which is carried on a vertical shaft. The shaft is suspended at the top in a specially designed anti-friction bearing, arranged so as to reduce the power required for operation to a minimum. The water is admitted into the top of the washer and overflows from section to section through the gas ports, the dirty water saturated with dust leaving the bottom of the washer.

When the shaft revolves, the cones do likewise, and the water is raised by centrifugal force along the inner sides of the cones and is atomized at the upper edge. This upper edge of each cone is a little higher than the next outer one, thereby forming a certain number of horizontal sprays of water, depending on the number of cones. The upper portion of the outer cone, which is somewhat higher than the inner one, is perforated. The inner cones supply water to the perforated surface of the outer one. This results in the formation of a series of cascades composed of very small drops of water, through which the gas must pass en route through the apparatus.

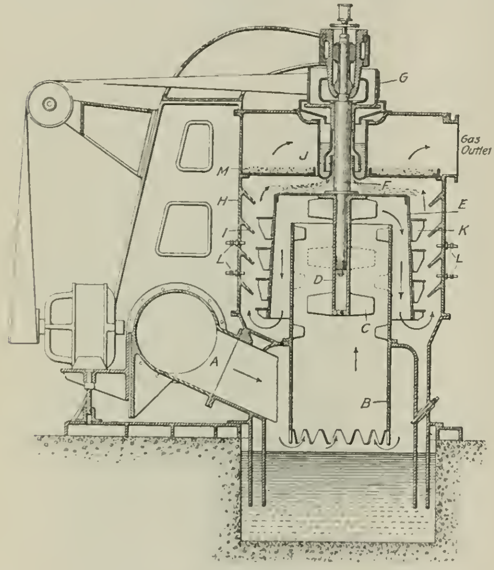


FIG. 23—RECO CENTRIFUGAL GAS WASHER

The washing is accomplished mostly in the lower sections, while the upper sections perform primarily the function of cooling the gas.

For primary washing, the Feld washer is constructed with seven chambers or sections, the lower three being the washing chambers, the fourth one being a separating chamber and the upper three being the cooling chambers. For final washing, in the case of the gas being required for gas-engine purposes, the gas after being primarily cleaned is passed through an additional washer of the same general arrangement.

### RECO CENTRIFUGAL GAS WASHER

This gas washer is constructed by the Roessing-Ernest Company, of Pittsburgh, Pa., and is designed to cool, clean and, if necessary, dry the gas in one apparatus. This washer consists substantially of a vertical outer casing, a tube whose lower end is provided with serrations extending to within a few inches of a water seal, a revolving inverted cup, and a sleeve casing attached to the inverted cup. The outer casing, the cup, the tube, and the sleeve casing are provided with shelves and vanes. The apparatus is belt-driven. The spindle of the rotor on which the driving pulley is fastened is hollow, and the weight of the rotor is taken up by the shaft inside of this sleeve held by a ball bearing which is backed by a rubber buffer in order to equalize any irregularity during rotation.

As shown in Fig. 23, the hot gas enters the apparatus at the point *A*, passes over the water, a certain amount of which the gas takes up by evaporation, and then passes into the tube *B* through the serrations at its base. During its passage through this tube the gas and water vapor are subjected to a thorough beating and mixing by the action of the vanes *C* of the revolving sleeve casing *D*, fastened to the top of the inverted cup *E*. The gas passes into this inverted cup, which is rotated by the driving sleeve *F* and the pulley *G*, and then flows downward, around and under the lower edge of the cup and then upward between the cup and the outer casing *H*. The outer surface of the revolving cup is provided with concentric shelves *K* and the outer casing *H* is provided with downwardly inclined shelves *I*, which receive the washing water from the water-sealed stuffing box *J* and through a series of water pipes *L*. The water, falling on the rapidly rotating shelves of the cup, is thrown by centrifugal force against the inner walls of the casing and thence flows downwardly along the inclined shelves, dripping on to the next rotating shelf, and so on. In this way the gas, while subjected to a thorough whirling and beating action, has to pass upward through several films of finely divided water or spray while the water passes downward, carrying with it the separated impurities.

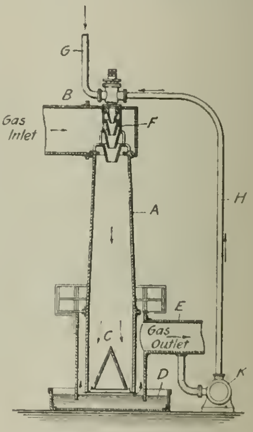


FIG. 24—SEPULCHRE GAS WASHER

The apparatus operates on the counter-current principle, the cleanest gas passing from the apparatus meeting the cleanest water entering the apparatus.

The upper part of the casing is provided with a rack which, it is stated, can be packed with suitable drying material in case it is desired to dry the gas before leaving the apparatus.

### SEPULCHRE GAS WASHER

This system is designed as a final washer to further clean primarily cleaned and cooled gas to the degree necessary for use in gas engines. The principle of this system consists in creating in a vertical tower a very fine spray or mist of water by means of an injector of the Körting type, in which water under pressure is atomized by means of compressed blast-furnace gas, the spray being produced by the expansion of the compressed gas. An intimate mixture of the spray so formed, with the dirty gas entering the apparatus, is obtained by the arrangement of the apparatus.

A separator is provided in connection with this apparatus, which consists substantially of a cone arranged in the lower part of the tower in such a way as to leave between the base of the cone and the walls of the tower a very narrow passage, through which the gases are forced over the surface of a water seal, where the dust and water vapor are deposited.

In the accompanying drawing, Fig. 24, *A* is the vertical tower, the lower end of which terminates a short distance above the surface of the water seal *D*. Within the lower end of the tower is arranged a conical deflector, *C*, and near the top of the tower is the gas inlet, *B*. The lower section of the tower *A* is surrounded by a casing which is open at the bottom and extends beneath the surface of the water in the seal.

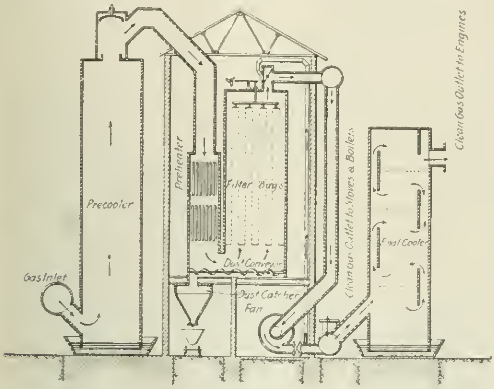
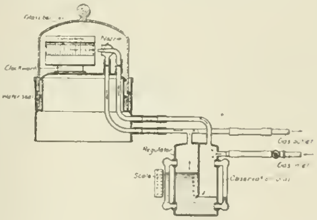


FIG. 25—HALBERGER-BETH GAS-CLEANING SYSTEM

A gas outlet, *E*, is provided in connection with the outer casing. The Körting injector is located at *F* and the feed water for same is supplied through the pipe *G*. The pressure is supplied by withdrawing a portion of the purified gas from the outlet pipe *E* and forcing this by the compressor *K* through the pipe *H* into the injector simultaneously with a stream of water.



### FINAL DRY CLEANING

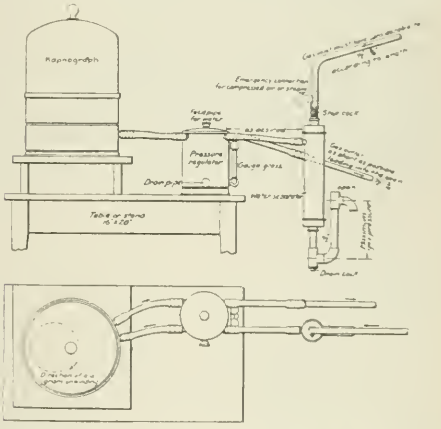
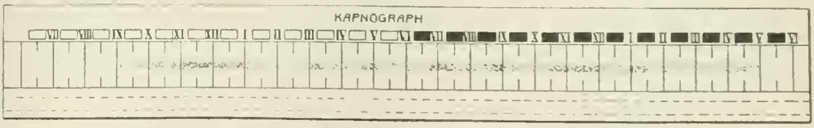
(Some of these systems can also be applied to primary cleaning.)

### HALBERGER - BETH GAS-CLEANING SYSTEM

The principle of the Halberger-Beth system, shown in Fig. 25, is based primarily on filtering the gas through canvas bags. The gas coming from the blast furnace passes through the usual dust catchers and gas mains to a cooling tower, where the temperature of the gas is reduced to about 175 deg. Fahr. The cooling tower is arranged so that the necessary amount of cooling can be accomplished either by air or by direct contact with water, depending on the temperature of the gas entering the cooler, which temperature is naturally variable, in accordance with blast-furnace conditions.

From the cooler, the raw gas, by means of the suction of a fan placed beyond the filters, or without a fan when the pressure of the gas issuing from the furnace is sufficient, passes into and through the canvas filtering bags, depositing its impurities on the surface of the bags. These canvas filters are contained in a series of double compartments, each usually holding twelve canvas bags in rows of three by four. Each bag is about 8 in. in diameter by 9 ft. 9 in. long, and is equipped with a ring at each 18 in. of its length to prevent entire collapse of the bag when cleaning. The bags are fastened into a stationary header at the bottom, this bottom end being open, while the top is closed by a steel plate. Each bag is connected with a shaking mechanism located outside and above the filter compartment, and at regular intervals, usually about every four minutes, these bags are automatically shaken, a compartment at a time, for a period of from fifteen to twenty seconds. By means of a butterfly valve, the uncleaned gas is shut off from the compartment while the shaking is in progress, and cleaned gas, superheated to the proper temperature of about 175 deg. Fahr., is forced under pressure into the compartment. This causes a partial collapse of the canvas bags, which, in conjunction with the simultaneous shaking, allows the dust to fall from the canvas. The separated dust drops into a hopper beneath the sacks, whence it is transferred by means of a spiral conveyor to a bin, from which it is loaded into cars. At the end of the cleaning period the butterfly valve automatically returns to its original position and filtering commences again.

It is quite necessary to keep the temperature of the gas at about 175 deg. Fahr., as if much higher than this there is danger of scorching the bag, while if lower the water vapor in the gas is deposited on the canvas and prevents proper filtration. In case the gas becomes cooled below 175 deg. Fahr. in the cooling tower, it is superheated by means of steam or by waste heat from the hot-blast stoves to about this temperature before entering the filtering bags. After leaving the canvas bags, the gas requires no further cleaning

*Specimen of strip indicating one days run at a European Gas Engine Plant*

FIG. 29—THE KAPNOGRAPH

for gas engines and is cooled down to the proper temperature in cooling towers of various designs.

The degree of cleanliness of the gas is indicated by the clearness of the effluent water from these towers and no settling basins are required. Consequently, this water can be used over and over again, which is a material item in districts where water is scarce. A further advantage lies in the non-pollution of streams, the laws relating to which are very strict in certain districts.

This system utilizes the basic principle employed in the "bag house" system, which has been used for the last twenty years in connection with recovering zinc dust from the gas issuing from zinc oxide furnaces and collecting dust from lead smelters.

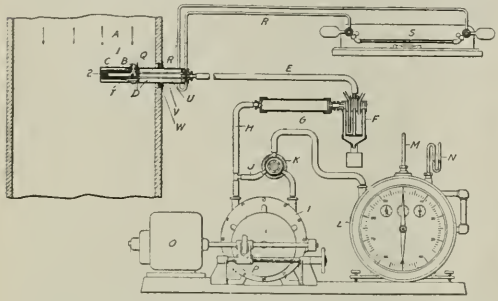


FIG. 30—THE BROWN DUST, MOISTURE AND VOLUME DETERMINATOR

THE KAPNOGRAPH

This instrument, shown in Fig. 29, continuously indicates the relative degree of cleanliness of the blast-furnace gas going to the gas engines, and is extensively used in European gas-engine stations. Gas from the cleaned gas main passes through this apparatus and impinges upon a continuous recording chart, upon which the dust in the gas is deposited. The variations in the amount of dust in the gas are indicated by lighter or darker shades on the recording paper, depending on the amount of dust deposited. The flow of gas to the instrument is maintained either by the natural pressure of the gas, or, if this is not sufficient, by an aspirator behind the outlet pipe. The speed of the gas to the nozzle is kept constant by means of a regulator, as shown in sketch, the excess gas over the required amount escaping into the outlet pipe by passing under a partition and through a seal of water.

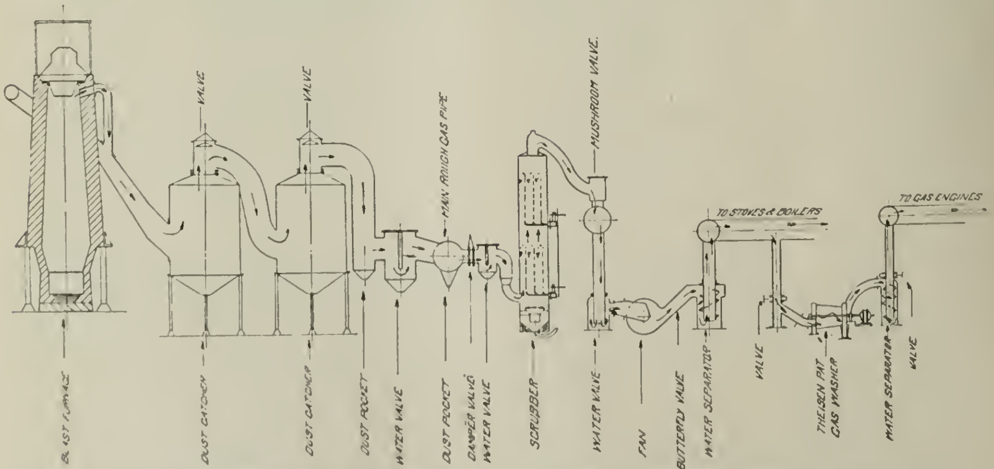


FIG. 32—THE COURSE OF THE GAS THROUGH THE CLEANING PROCESSES TO STOVES, BOILERS AND ENGINES

METHODS OF DETERMINING THE AMOUNT OF DUST IN BLAST-FURNACE GAS

A method employed with good results in Europe for determining the amount of dust in the gas consists in drawing a definite quantity of the blast-furnace gas to be tested through a filter, which is weighed in a dry condition before and after the test. The apparatus for determining the amount of dust consists of a glass tube drawn out at one end and fitted at the other with a ground-glass cover which is also drawn out to a thin tube. This cover facilitates the placing of the filtering material in the tube, and during the test the cover is fastened to the tube by means of wire. Before the test, the glass tube, filled with suitable filtering material, is placed in a drying furnace and heated at a tem-

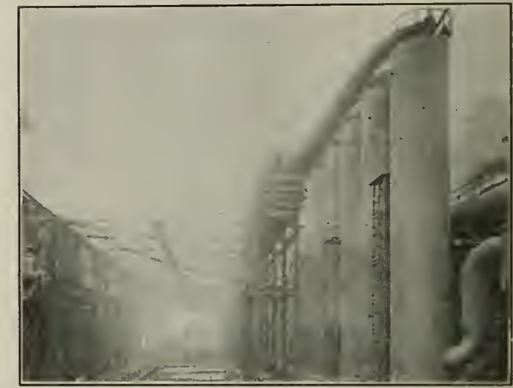


FIG 31—DUQUESNE GAS-CLEANING PLANT, SHOWING SCRUBBERS, WITH INTAKE FROM DIRTY-GAS MAIN AND OFFTAKE TO COLLECTING MAIN; ALSO SETTLING BASINS

perature of 105 deg. C. until its weight is constant, which usually requires from one to two hours. The drying furnace is arranged so that several tubes can be dried simultaneously.

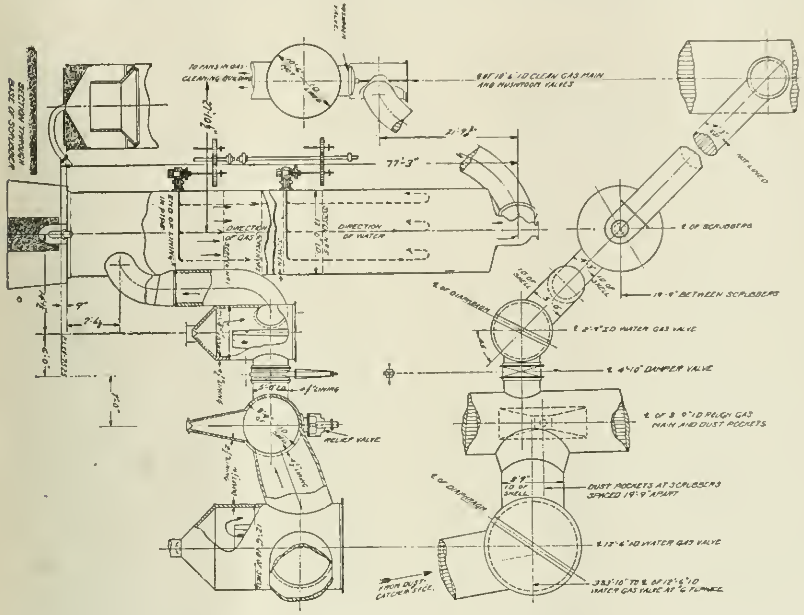

SECTION THROUGH BASE OF SCRUBBER
TO FANS IN GAS CLEANING BUILDING
9'6" 10'6" I.D. CLEAN GAS MAIN AND MUSHROOM VALVES
NOT LINED
21'-9⅛"
77'-3"
DIRECTION OF GAS
DIRECTION OF WATER
END OF LINING IN PIPE
℄ OF SCRUBBERS
19'-9" BETWEEN SCRUBBERS
℄ OF DIAPHRAGM
℄ 2'-9" I.D. WATER GAS VALVE
℄ 4'-10" DAMPER VALVE
5'-0" I.D.
℄ OF 3' 9" I.D. ROUGH GAS MAIN AND DUST POCKETS
RELIEF VALVE
DUST POCKETS AT SCRUBBERS SPACED 19'-9" APART
℄ 12'-6" I.D. WATER GAS VALVE
FROM DUST CATCHER S'FCE.
383'-10" TO ℄ OF 12'-6" I.D. WATER GAS VALVE AT "G" FURNACE
7'-6"
9"

FIG. 33—SECTION THROUGH THE SCRUBBERS SHOWING THE METHOD AND APPARATUS FOR PRIMARY CLEANING. THE CUT-OFF VALVES ARE ON THE SIDE AND DRIVEN FROM A VERTICAL SHAFT

During the drying process air is drawn through the tubes after having previously been thoroughly dried by passing through bottles containing calcium chloride and concentrated sulphuric acid. During the drying process the tubes are weighed until no further increase in weight is observed.

In making the test, the weighed tube containing its filtering material is inserted into the gas main, a rubber stopper keeping the test-hole tight. The upper end of the tube is connected with a gas meter, which in turn is connected with a barrel filled with water. The water is allowed to flow out of the barrel and in so doing creates the necessary suction to draw the gas through the filtering tube and through the gas meter. When the necessary amount of gas has beën withdrawn the tube is again dried and weighed. The increase in weight indicates the amount of dust in the quantity of gas tested.

## BROWN DUST, MOISTURE, AND VOLUME DETERMINATOR FOR BLAST-FURNACE AND OTHER GASES

This apparatus has been devised in order to accurately determine the amount of dust and moisture contained in blast-furnace gas, as well as the volume of the gas, and is used iwth considerable success.

Referring to the accompanying drawing, Fig. 30, *A* is a gas main conveying the gas to be tested. *B* is an aperture in the small pipe through which samples of the gas are drawn. *C* is a filtering medium within which the solid constituents of the gas are deposited. *D* is a conduit leading to the exterior of the gas main through which the filtered gas is conducted. *E* represents a flexible connection to a surface condenser, *F*. *G* represents a receptacle for some chemical, such as calcium chloride, which can be used for the purpose of taking out the moisture contained in the sample. *H* is a conduit from this moisture-removing receptacle to the rotary air pump, *I*, or through the by-pass *J* to the three-way valve *K* and thence to the gas meter *L*, where the volume of the sample is determined, together with its temperature and pressure; these latter by means of the thermometer *M* and the U-tube *N*, respectively. An electric motor, *O*, is used to operate the pump *I* through the variable-speed drive *P*.

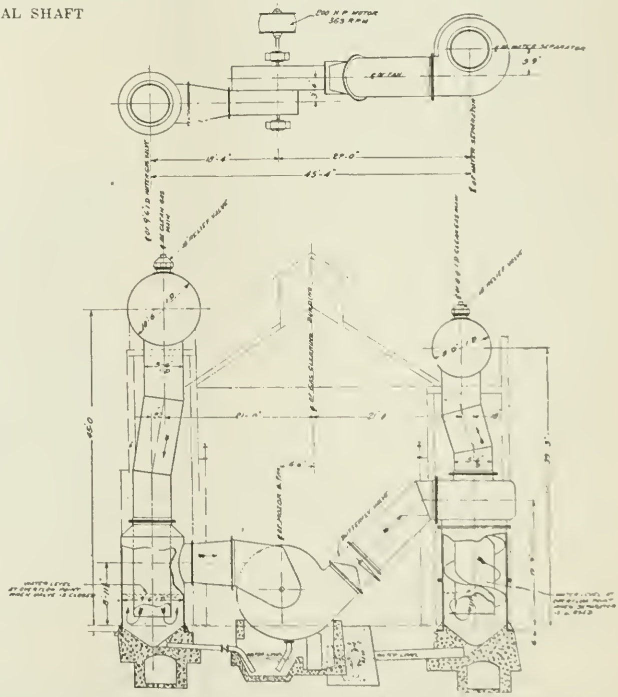


FIG. 34—SECTION THROUGH FANS, AND METHOD OF PASSING GAS THROUGH SEALS AND SEPARATORS

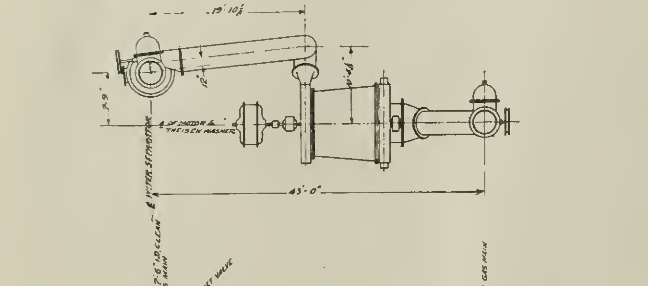


FIG. 35—SECTION THROUGH THEISENS, SEALS AND SEPARATORS

An indication of the velocity of gas or gases in conduit *A* is transmitted through aperture *Q* in the sample pipe and conduit *R* to horizontal pressure gauge *S*; also an indication of the velocity of gas or gases after passing aperture *B* is transmitted from aperture *T* through conduit *U* to horizontal pressure gauge *S*. It is evident that changes of the velocity of the gas or gases in aperture *B* of sample pipe, produced by the suction of pump *I* or by pressure in gas main *A*, are indicated, and can be accurately controlled and made equal to the velocity of the gas or gases in conduit *A*, the gas main, such indicator being the oil piston shown in glass tube forming a part of the velocity gauge *S*.

The method of operating this apparatus is as follows: The dry weights of the filtering medium *C*, of the receptacle *G*, containing the calcium chloride, and of the measuring flask attached to surface condenser *F*, are very carefully determined. They are then inserted in the apparatus, and the sample pipe is then inserted in the gas main, a tight connection being made between flange *W* and bushing *V*. The meter reading is noted. At the same time that the sample pipe is inserted in the gas main *A*, the time is noted, and the rotary pump *I* started. The speed is then so regulated that the oil piston in the horizontal pressure gauge *S* is maintained in equilibrium. This indicates that the velocity in aperture *B* is exactly equal to the velocity in gas main *A*, this condition having been determined by a measured amount of gas in gas main *A*, and the proper proportioning of aperture and conduits in the sample pipe during the calibration tests. This condition is maintained for an indefinite length of time and the sample pipe is then withdrawn from gas main *A*. The meter reading, multiplied by the ratio of area of aperture *B* to area of gas main *A*, gives the total amount of gas passing through gas main *A* in the elapsed time. The difference between the dry weight of the filtering medium *C*, before and after the test, divided by the number of cubic units shown by the meter, gives the weight of dust per cubic unit. The moisture per cubic unit of gas is found in a similar manner from the sum of the weights of the water in drying receptacle *G*, the water caught in the measuring flask attached to surface condenser *F*, and the weight of water retained in the filtering medium *C*.

Figs. 31 to 36 are reproduced from Mr. Diehl's paper as showing approved types of construction. The text of Mr. Diehl's concerns itself principally with operation and will be quoted in dealing with that subject.

In addition to the processes so clearly described by Mr. Forbes, there are various others designed to remove the dust from the gas in the dry state, but as these have had no extensive application for the blast furnace process, they may be omitted here.

Even since the time of Mr. Forbes' paper there has been an extensive development in Europe of the Halberger-Beth process of which there are now almost thirty plants in use in Europe and the number has been rapidly increasing. American furnacemen have been slow to take up this process and have acted in this matter along the same line as in many other cases; where an apparatus requires careful supervision or where its maintenance charges are high, operating economies secured by its use are disregarded. The same has been true in regard to the gas engine, by-product coke-oven and many other kinds of apparatus.

FIG. 36—DIRTY-GAS MAIN WITH CLEAN-GAS MAIN AT HIGHER LEVEL, ALSO THE END OF THE REFINED-GAS MAIN LEADING FROM THE THEISENS TO THE ENGINES

This attitude is one often censured not only by foreigners, but also by Americans who do not consider all the aspects of such problems, particularly the financial one. The relative cheapness of capital and supervision and the costliness of raw materials in Europe as contrasted with the high cost of capital and supervision in America and the low cost of raw material constitute in no small measure a justification for the American attitude.

There is reason to hope that a process may soon be developed superior to either the wet processes or bag filtration plant and less complicated and difficult of maintenance. I refer to the Cottrell process for the electrical precipitation of the dust by a high-tension direct current passing through the gas column. This process has been developed to complete success in several lines of industry but its sponsors have hesitated to attack the blast furnace problem on account of its size and the complexity of the conditions. If this process shall ever be worked out to a commercial success it will furnish gas absolutely clean with no loss of temperature and with no increase in its moisture. These are the ideal conditions for the use of furnace gas for combustion purposes. For the gas engine it must in any event in present practice be cooled about to atmospheric temperature and this, of course, can easily be done after the gas is removed by a direct spray. Perhaps the time might even come if hot cleaned gas were available that the gas engine could be adapted to its use and thereby further increase its economy.

In conclusion it may be said that it is impossible at the present time to write a history of gas cleaning. The whole development of the subject in this country covers barely ten years in all and nine-tenths of it has been in the last seven or eight years. The advantages have become manifest and all furnacemen have sought *a* way rather than *the* way to clean the gas and undoubtedly they were right in this course for the plants installed early, even though not the last word of perfection in the subject, will have paid for themselves in bettered operating conditions before the much-to-be-desired best method is developed. It is possible, therefore, with this rapid development in progress, to give only an outline of the subject and to state briefly the principles which underly its application. To do this has been the attempt of the present article.

## Treating Sulphurous Fumes at the Mammoth Smelter

BY AL H. MARTIN

The smelter and baghouse of the Mammoth Copper Mining Company are located at Kennett, Cal., a station on the Southern Pacific Railroad. Control of sulphurous fumes has been a vital problem practically since the commencement of operations, owing to the unfriendly attitude of the neighboring farmers and their complaints of alleged damage by smelter smoke. The baghouse system has been in successful operation about five years, and recent improvements have materially increased its efficiency. The baghouse system was first employed by the Mammoth Copper Mining Company, as relating to copper smelting, although its merit had previously been demonstrated at several lead-smelting plants, and has proved superior to the many contrivances tried in the Shasta field by other operators. Its efficiency is proved by the fact that the Mammoth is now the only smelter operating, while less than eight years ago three other plants also were in action.

The ores of the Mammoth mine are sulphides in the form of massive pyrites, with a large percentage of chalcopyrite. The average copper content ranges from 3 to 5 per cent, together with 4 to 5 per cent zinc and \$1.50 to \$2 in gold and silver per ton. The zinc is a valuable aid in neutralizing the sulphurous properties of the fumes, and gives no trouble in smelting. The blast furnaces are five in number, with three generally in operation. Each furnace has a tuyere dimension of 50 in. by 180 in. and has a capacity slightly in excess of 400 tons of charge per twenty-four hours. About three-fourths of this is ore, the balance consisting of silicious gold-bearing ore, lime and coke.

The fumes from the furnace hoods are led through steel goosenecks into two hopper-bottom brick flues. Each flue is 260 ft. long, and during the passage of the smoke large quantities of the dust settling from the heated fumes drop through the hopper bottoms into a brick-and-steel collecting chamber. From this chamber the fumes are passed into a compartment by means of four round steel pipes at the base of the former smokestack. These pipes are 100 ft. long and 8 ft. in diameter. The second chamber terminates in a flue 15 ft. square and 120 feet long. This guides the fumes into fan chamber which is of balloon-like shape, where the smoke is agitated and cooled by two Sirocco fans 11.5 ft. in diameter. Each fan performs 300 r.p.m. and is driven by a 400-hp electric motor. The fans not only cool the fumes but also serve to draw them from the furnaces and drive them into the baghouse proper.

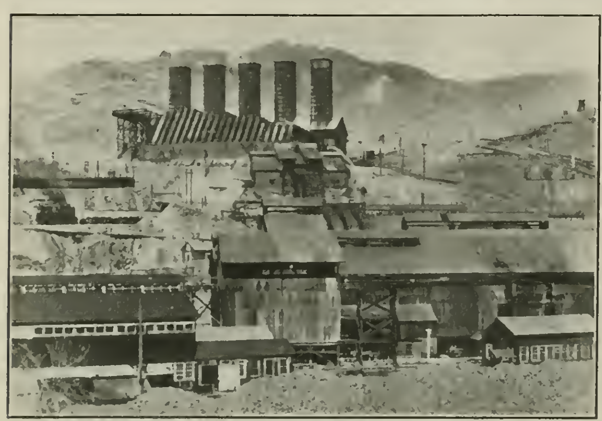
### Improved Arrangement of Cooling Pipes

From the fan chamber the fumes pass into the cooling pipes. There are fifty cooling pipes, arranged five to a section, each pipe having a length of 190 ft. with a 4-ft. diameter. The pipes are so arranged that the fumes pass for two-thirds of their length on a horizontal line, then emerge through a down-sloping section comprising a length of about 60 ft. Formerly the pipes were arranged in three sections. The fumes first passed through a sloping section, thence horizontally, and finally through the down-slanting portion. Tests proved better results were secured by driving the hot gases for a horizontal distance comprising two-thirds of the total length of each pipe. The complete system of cooling pipes embraces an area of 135,000 sq. ft., and the pipes have an aggregate length of 9500 ft.

The principal function of the cooling pipes is the reduction of temperature of the fumes to a point where they will not injure the woolen bags in the baghouse. The fumes have a temperature of 280 deg. C. at the fans, and this is reduced to 130 deg. at the discharge ends of the pipes, showing a loss of 150 deg. in the pipes. The fumes speed through the pipes at an approximate rate of 2700 ft. per minute and discharge into a distributing chamber. The fumes are still too hot for transmission to the bags and their temperature is reduced to 99.3 deg. by admitting cold air through the top of the chamber by means of twelve 24-in. pipes. A special fan supplies the cold air which serves to dilute the gases besides cooling them to the desired point. From this chamber the fumes pass into the baghouse through five short pipes.

The baghouse is 220 ft. long and divided into five bays, with four divisions to a bay. Each division contains 148 bags, or a total of 2960 for the complete plant. Each bag is woven of pure wool and is 34 ft. long with a diameter of 18 in. They are set 21 in. apart, center to center, and each five rows of bags is supplied with a hopper. The lower ends are secured to the floor and the upper edge suspended from vertical racks. The fumes enter the bags through their lower ends and filter through the woolen mesh, to finally escape through the five towers leading from the baghouse into the outer air. The wool catches the solids carried by the smoke and the bags are frequently given a vertical agitation to shake the settled dust into the hoppers lying below. A special shaking device invented by J. E. Egleston is used, the apparatus being operated by electric motors. A wooden trough partly filled with water lies at the bottom of each hopper and the collected solids are drawn off into tanks and settled.

The baghouse is closed with the exception of openings along the sides of the floor and roof, and there is no way for the fumes to escape save through the five towers provided for that purpose. The openings along the floor and roof permit the free entry of large quantities of air to dilute the sulphurous acid gas ($SO_2$). The zinc sulphide is converted into zinc oxide in the blast furnace, and as zinc oxide has a natural affinity for sulphuric acid gas ($SO_3$), this noxious fume is thus neutralized. But to make doubly sure hydrated lime is introduced at the fans at the rate of 30 lb. per hour, effectively neutralizing any vestige of the fume that might resist the action of the zinc.


MAMMOTH SMELTER SHOWING BAGHOUSE AND COOLING PIPES

### Pilot Bag Indicates Efficiency of Neutralization

That a constant test may be maintained to guard against any possible escape of sulphuric acid gas, the company operates a miniature woolen bag, about 2 ft. in length, in the distributing chamber. Should any acid escape, the bag would immediately be destroyed, and as long as the woolen fabric shows no sign of injury it is evident no acid is escaping. This test is maintained for the company's protection and forms a constant register of the efficiency of the practice, in case hostile agencies should claim to have detected traces of $SO_3$ in samples of the exterior air. Under normal conditions the volume of gas passing the fans is 333,000 cu. ft. per minute, and 100,000 cu. ft. of cold air is introduced per minute to reduce the temperature of the fumes. In hot weather it is necessary to use greater quantities of cold air, and the volume frequently reaches 125,000 cu. ft. per minute.

Tests of the smoke leaving the baghouse show that not a trace of dust or $SO_3$ escapes, and the volume of SO is reduced 0.4 to 0.6 per cent, by volume, although the law permits the escape of the gas up to 0.75 per cent by volume. The dust precipitated in the cooling pipes, hoppers and flues contains considerable lead, zinc, silver, gold and other metals, but is of little use to the company as a satisfactory method of treatment has not been devised, despite numerous and extended experiments. A small amount is briquetted and returned to the furnaces, but the greater portion is stored pending the perfection of an economical process for recovery of the metals. Fully 16,000 tons of the whitish-looking dust is stored near the plant, and this amount is increased daily. It is estimated that the metals thus lost would pay for the operating costs of the baghouse system could they be recovered on an economical basis. G. W. Metcalfe is manager of the Mammoth Copper Mining Company, and J. H. Kervin superintendent of the smelter.

## Chemicals Produced by the Aid of Electricity

According to the thirteenth census of the United States, in 1909 there were 34 establishments making chemical and metallurgical products by the aid of electricity, distributed as follows: Illinois, Maine, Maryland, Minnesota, Virginia and West Virginia, each, 1; New Jersey, 2; Pennsylvania, 3; Michigan, 5; New York, 18. Of the total value of products, New York reported $13,401,878, or 72.6 per cent; Michigan, $1,513,198, or 8.2 per cent; Pennsylvania, $903,196, or 4.9 per cent; and all other states $2,633,189, or 14.3 per cent.

The accompanying table shows the products and their value. The class "metals and alloys" includes aluminium, silicon, ferrovanadium, ferrosilicon, ferrotitanium, cuprovanadium, and other metals and alloys. Elements and compounds, produced by the aid of electricity specifically reported and included under the heading of "all other," are phosphorus, sodium, lead oxides, liquid chlorine, carbon disulphide, sodium carbonate potash and potassium bromide.

| | Number of establishments reporting | Quantity, tons, | Value |
|---|---|---|---|
| Calcium carbide | 4 | 60,973 | $2,984,001 |
| Caustic soda | 5 | 19,428 | 1,032,647 |
| Chlorates | 5 | 5,785 | 904,550 |
| Hypochlorites | 5 | 45,976 | 1,506,831 |
| Metals and alloys | 9 | ..... | 7,653,984 |
| Abrasives and electrodes | 4 | ..... | 1,415,799 |
| All other | 11 | ..... | 2,953,649 |
| Total | 34 | | $18,451,461 |

The most important class of products produced by the aid of electricity shown in the table as measured by value, is that comprising metals and alloys, which contributed 41.5 per cent of the total value in 1909.

**An Acid-Proof Lining for Ore Vats.**—In treating low-grade copper ore, one of the methods frequently employed is to dump it into large concrete basins and apply a 10 or 12 per cent solution of sulphuric acid. However, the difficulty encountered in this method is to get basins which will stand the effect of the acid. The usual procedure is to swab the interiors of the basins with an asphaltic mixture. The objection to this treatment is that the asphaltic coating is quickly destroyed by abrasion and has to be renewed at frequent intervals. Tests conducted recently in connection with the use of J-M acid-proof mastic, manufactured by the H. W. Johns-Manville Co., New York, for lining the acid basins, demonstrate that it is entirely successful in overcoming the difficulties heretofore encountered. Acid-proof mastic when laid 1½ in. thick, forms a tough, impervious coating which is unaffected by acid and successfully resists abrasion. The basis of this material is a pure natural asphalt which will give years of service in ore vats.

**The American Mining Congress** will hold its next meeting at Phoenix, Ariz., December 7 to 11, 1914. Methods of safety and efficiency in mining will be considered, and federal aid to the industry.

# Quantitative Blowpiping as an Aid to the Prospector

BY SIEGFRIED FISCHER, JR.

(*Concluded from page 695 of November issue*)

### The Gold and the Silver Assay

In this treatise we will take the gold and silver together. It will be readily seen if only one of these metals is present, to what step the process should be carried.

Weigh out 100 mg (1.5432 grains troy) of the carefully sampled material and place it in the small horn scoop, taking care to brush all of the ore off of the scale pan. Ores containing large amounts of sulphur, arsenic, zinc, or antimony after weighing, need a thorough roasting before making up the charge.

*Roasting.*—Dr. Richards' improved method for roasting is superior to the one given in most of the textbooks, and will be the only one described here. It needs a little more care, but saves greatly in time. On a piece of charcoal a small cavity is made with the charcoal borer. The ore is carefully brushed from the scoop into this hole and spread out along the face of the cavity with the ivory spoon, so that it forms a uniform thin layer. A very weak oxidizing flame is then applied to it, paying particular attention that none of the small particles of ore are blown away.

After a while the material will have caked slightly and then a strong oxidizing flame is applied until no more fumes arise and no odor of $SO_2$ is observed. If this operation has been done carefully the material will have formed a cake which may be readily turned by carefully inserting a knife point at the edge and then turning. The turned side is then strongly roasted and after no fumes and no $SO_2$ odor is observed the sample is ready for the charge, brought back into the scoop and mixed with the necessary ingredients.

The charge will vary according to the ore, and it is difficult to give an absolute rule for making up this charge, but the following will about cover all purposes.

*Borax-Glass.*—The amount used depends upon the fusibility of the ore and upon the amount of materials to be slagged off. One hundred mg will usually suffice. If, however, the ore is hard to fuse due to large amounts of iron, cobalt or tin, more borax-glass must be added during the melting down of the charge.

*Test-Lead.*—As a general rule it is better to use too much test-lead than too little. The amount to be used depends on the amount of other metals present in the ore.

Ores carrying less than 7 per cent Cu or 10 per cent Ni use 5 Zentner (500 mg) test-lead per 100 mg ore. Anything above these amounts will be covered by using 20 Zentner (2000 mg).

Tellurium requires the same amount, i.e., 20 Zentners.

Speiss will use between 10 and 15 Zentners.

Ores containing tin will demand about 7 Zentners.

*Sodium Bicarbonate.*—This flux is mostly used for acid ores, and in small amounts where Cu is present. It forms easily fusible slags, it oxidizes iron and tin, which then pass into the slag, and acts also as a desulphurizer. The amounts to be used depend greatly on the nature of the ore and the function which the soda is supposed to perform. So it is nearly always used with ores carrying sulphur even though they were previously roasted.

A good all-around charge to use in connection with gold and silver ores is the following one:

| | |
|---|---|
| Ore | 100 mg |
| Test-lead | 1500 mg |
| Borax-glass | 100 mg |
| Soda | 50 mg |

The ingredients, after having been weighed out, or measured out, the test-lead in the particular measure, and the borax-glass and the soda in the ivory spoon (one spoonful 100 mg), are brought into the horn scoop with the ore and thoroughly mixed, made up in the soda paper as previously described, and are then ready for the melting down.

*Melting Down.*—Near the end of one of the wide faces of a piece of charcoal bore a hole not too deep. Into this place the charge wrapped in the soda paper so that the bottom is toward the flame of the blowpipe and the side of the little package rests on the side of the cavity farthest from the tip of the blowpipe. Fig. 7 will make this clear.

Now apply a pure but not too strong reducing flame covering the total assay. This will carbonize the paper and melt the charge. When all is melted down, a strong reducing flame is applied. Most of the metals, and some united with sulphur and arsenic, will unite with the lead and melt with it to a button. Earthy materials as well as hard reducible metallic oxides and a small amount of the easily reduced metals melt with the borax to a slag.

To insure a complete collection of the lead, the charcoal should be kept in motion by turning back and forward. The lead should all be in one button and so should the slag. The latter must be in an easily fusible state. If slag is sticky and black, it shows basicity and borax must be added. If stringy and clear, the slag needs more soda. A good lead button should be white. If it is black, it still contains sulphur and must be oxidized. This is done by heating the lead button carefully with the tip of a fairly strong oxidizing flame. Lead oxide will go into the slag but no gold or silver.

This oxidation should continue until the surface of the lead button is light yellow, due to a thin layer of lead oxide. Do not heat too high or spattering will take place, causing a loss of values. When the button has the correct appearance, the charcoal is slightly inclined to insure total collecting of the lead melted, treated with a reducing flame, and the charge poured hot on the anvil. Usually only the lead will pour out, the slag remaining in the cavity. The lead on the anvil is hammered to a cube and is then ready for scorification.

*Scorification.*—This is done on a cupel. Fill the cupel mold with bone-ash, press the stamp down firmly and give the stamp two or three sharp taps with the hammer. On removal of the stamp the cupel should be absolutely smooth. Place the mold in the holder, and grasp the wooden holder between the thumb and the index finger of the left hand, allowing the flat bottom to rest on the bent little finger of the same hand. The cupel is then freed from moisture by heating.

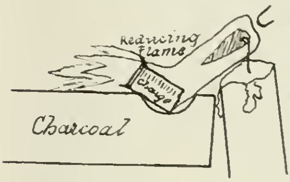


FIG. 7—ARRANGEMENT FOR MELTING DOWN

When dry the small button is placed in the middle of the cupel with a pair of forceps. The cupel is slightly inclined towards the blowpipe, and a reducing flame applied to reduce oxides on the surface of the button until it is melted down. Then the assay is treated with a strong oxidizing flame.

Scorifying should be done quickly. The lead will form litharge which is partly absorbed by the cupel. Much of it, however, stays in the liquid form surrounding the ever-decreasing button. When the surface of the button as seen is about 3 mm in diameter the melt is allowed to cool.

When set the mass is removed from the cupel, placed on the anvil, and the little button freed from litharge and bone-ash by hammering. It is good practice to clean the button by brushing with a glass or stiff-haired brush. The small, clean button is then ready for the fine cupellation.

*Fine Cupellation.*—Use a new, dried cupel. Place the little button on it so that it lies near the left edge. Incline the holder so that the little button cannot roll towards the blowpipe. Heat the button with a nearly vertical oxidizing flame until it melts.

When melted, take flame off the button and heat the bone-ash immediately surrounding it, rotating the holder with the two fingers so that the button will always come in contact with a fresh surface of bone-ash. The button will thus describe the path of a spiral toward the center of the cupel. The litharge will be absorbed by the cupel and, when the last trace of the oxide is removed, the button suddenly brightens. Then the operation is completed. This sudden flaring up is termed "brightening."

If silver alone is present this is the final operation and it only remains to weigh or measure the button. If the button is a large one it may be weighed, if small measured on the Plattner scale. *A large button may be flattened on the anvil, cut in half, each half put on cupel with test-lead brought down to new buttons and then measured on scale and weights combined.* The operation of measuring on the Plattner scale has already been described.

If the button is an alloy of silver and gold, then another operation is required, namely, parting.

*Parting.*—Under this term is understood the separation of the gold and silver. This is usually done by treating the button with nitric acid. The button is placed in a small porcelain dish. A drop of concentrated nitric acid is added to it and one or two drops of water. Holding the dish between thumb and index finger of the right hand, it is slightly inclined so as to have the button and acid in one place, and then gently heated over a flame. As the button is attacked, an evolution of heat will take place.

One cannot be careful enough here, because if spattering becomes very strong the small particles of gold will fly out of the dish. When the activity ceases, water is added. This is then carefully decanted, or, according to Dr. Richards, a small piece of filter-paper is so folded that it forms a fairly sharp angle. With the tip of this the solution is absorbed.

Wash again and repeat the treatment with strong nitric, washing finally twice.

This leaves the gold in a brown spongy mass. If the reaction was not too lively, all will be together. At times, however, the gold will be in several particles and these must be all collected. To gather the gold it is best to cut a small piece of test-lead from the solid piece, put it on the point of the forceps with the clean surface down, and then press this surface hard against the small gold particles. They will stay on this surface without difficulty and may be thus collected. This test-lead holding the gold is then cupelled to a button.

There is one thing which must be remembered, and that is, that not all alloys of gold with silver will be attacked by nitric acid. The button must have more than 50 per cent of silver. At the mint one-third gold to two-thirds silver is customary. If the button by its color shows that the gold predominates, then silver foil is added to make the ratio correct. The button, after having been weighed or measured to ascertain its total weight, is wrapped in the required amount of silver foil, folded into a small piece of test-lead and cupelled down to a button and then parted as before.

The final gold button is weighed or measured. If the alloy was weighed, the difference between it and the weight of gold will give the weight of silver.

If it has been measured it will only give the volume and not the weight. All measurements on the ivory scale give the volume and the figures giving percentage or weight have been calculated from the volumes. As I am going to describe the use of Dr. Richards' scale it will be unnecessary to describe the procedure on the ivory scale as it is similar to Dr. Richards'.

In connection with this I would like to mention the use of Dr. Richards' scale. The button of the gold and silver alloy is dropped into the groove several times and the diameter noted. The mean of the maximum readings is used as the correct one. In the table that accompanies the instrument the weight of silver is found, if the button is all silver. Dividing this weight by the specific gravity of silver, 10.073, we obtain the volume of the alloy.

After the parting the gold button is also measured in the same way. Its weight is divided by the specific gravity of gold, giving the volume of the gold button. Both these volumes are in mm³.

Subtracting the volume of gold from the volume of alloy gives the volume of silver.

Multiplying the corresponding volumes by the specific gravity of gold and silver will give the corresponding weights of the two metals, from which the ounces or percentages can readily be calculated.

$$\text{Scheme: Alloy } \frac{\text{mg silver}}{\text{spec. grav. silver}} = \text{volume of alloy in mm}^3$$

$$\text{gold } \frac{\text{mg gold}}{\text{spec grav. gold}} = \text{volume of gold in mm}^3$$

Vol of alloy — vol. of gold = vol. of silver in mm³.

Vol. of silver × spec. gravity of silver = weight of silver in mg.

Vol. of gold × spec. grav. of gold = weight of gold in mg.

For convertion of mg into ounces see description of Plattner's scale.

*Precautions in gold and Silver Assay.*—If tellurium is not all eliminated it goes into the lead button and in final cupellation shows deleterious effects. It lowers the surface tension of the lead, causes it to spread out, forming separate globules, each of which contains some of the values. These small buttons cannot be collected. So it is essential to obviate this effect by adding enough test-lead to the initial charge.

It is essential that the little silver or alloy button be cooled slowly to prevent sprouting, due to the absorption of oxygen while hot which is liberated again immediately before cooling, causing a loss by spattering.

If during cupellation some bone-ash becomes loose it at times happens to collect on the button. When this occurs, take a little piece of test-lead, place it on the button and melt. It will melt together with the button, increasing the mass of same, and by inclining the cupel the button will liberate itself from the bone-ash.

If much copper is present in the assay one cupellation is not sufficient. More test-lead must be added to the button during the process and cupellation repeated until the button is free from all copper. If copper is still present after first fine cupellation the button will have a flattened appearance, and at times shows black spots of copper oxide.

The heating is another important factor in the fine cupellation. If the button is heated too high, silver will volatilize. If not high enough the litharge around the button solidifies and sticks to cupel. If this occurs, increase the intensity of the flame. The heating should be such that the litharge is absorbed rapidly by the cupel.

Removing the button from the cupel requires some care. To prevent the losing of the button it is always advisable to work over a sheet of paper with edges turned up, thus forming a tray. When the button has cooled on the cupel it may be carefully pried loose from the same with the blade of a penknife, and then lifted out with the forceps, being sure that there is no pressure exerted which might change the shape of the small, nearly spherical granule. The button may also be removed from the cupel with the button pliers. One should remember always to handle it so that its form is retained. The button is then thoroughly cleaned from bone-ash by rubbing it gently with the tip of the finger on a piece of filter-paper, or with a brush.

### The Copper Assay

In this operation it is desired to retain the copper in the melting-down process. If the ore contains sulphur, arsenic, antimony or zinc it must be roasted, after weighing out the sample. One hundred mg of the ore is used for the assay. This is mixed with 5 Zentners of test-lead and enough borax to make an easily fusible slag. Mix the ingredients of the charge and make up in the soda paper. Melt down on charcoal as previously described.

The slag should have a black appearance and show no red coloration. If red shows in slag, copper has been oxidized and must be reduced back to metallic copper by rolling the button around in the slag under the action of the reducing flame. Another method is to add a small piece of test-lead to the assay. This lead on melting, together with the button, will take up the reduced copper, and the process can continue.

If the borax sticks to the charcoal increase the heat of the reducing flame. When the charge is thoroughly melted down and all the metal collected it is poured on the anvil and hammered to a button.

Make a new hole in the charcoal and place button into it with crystallized boric acid. As this fuses harder than borax, a hotter flame is required. Melt first with reducing flame, and then oxidize. The lead forms an easily fusible lead borate of a greenish color. If there is any red indication it shows loss of copper.

To get copper out of slag, if any was lost in this manner, apply the reducing flame while rotating the button in the slag until the red coloration has disappeared. Loss in copper can be readily observed by the slag showing a sealing-wax red color in the light of the luminous flame.

The slag must always be kept fluid, and as long as this is done one may rest assured that the button is in a liquid form. When the slag commences to bubble, it shows that the maximum amount of borate possible has been formed. Any more heating will not aid the operation, but the charcoal will reduce some of the lead in the slag back to metallic lead.

When bubbling starts allow button to solidify, and while slag is still pasty remove the button with the forceps and immerse it in water, which is kept close in one of the small porcelain dishes. This immersion in water cleanses the button from adhering slag. Dry on filter-paper, place the button on a new place on the charcoal with fresh boric acid and oxidize carefully. Repeat this as often as required.

When the lead content gradually decreases, the button becomes harder and harder to fuse. The lead color disappears and the copper color takes its place. The melted button will assume a nile-green coloration when copper is reached. On cooling the metal left will have a salmon color if pure.

If the button is finished it should be malleable, and when flattened out on the anvil it should show no cracks along the edges. If edges show cracks the button must be treated again with boric acid and newly tested. After assuring oneself of the purity of the metal button it is weighed, and if the ore contains only the copper as values the operation is completed.

If gold and silver were also present in the ore, they will be contained in the copper button. After weighing this it is brought onto a cupel with test-lead and fine cupelled. This button will then contain the gold and silver, and is weighed or measured. Its gold content is then determined by parting, and the results interpreted as described under the heading of gold and silver.

With a little practice and care no hole need be bored in the charcoal for treatment with the boric acid. Simply place some crystals of boric acid on a flat surface of the charcoal and melt it down. Then place the button on the melted acid and treat it as above described. This method saves time and one has a better opportunity to observe what is taking place.

### Cobalt and Nickel Assay

These metals as well as iron must be bound to arsenic to enable their qualitative determination. If copper is also present, it may be obtained as arsenide also. As a rule, ores carrying nickel will also contain cobalt and vice versa. The operation is based on the principle that when these metals occur together they may be successively oxidized out in the presence of borax, iron going first, then cobalt, nickel and copper.

Nickel, iron, cobalt ores not in the arsenide form must first be arsenicised. This is done by mixing 100 mg of the ore with 100 mg of powdered arsenic, wrapping the mixture in a soda paper, and placing the tightly and well-packed capsule in a test tube, heating this carefully in the non-luminous flame (alcohol lamp) at first, then increasing the temperature until the tube is red hot. The tube should be turned about its axis to prevent the charge in the soda paper from adhering to the glass. An arsenic mirror will form on the sides of the test tube, and when this does not seem to increase any more, the operation is completed. The charred paper containing the now arsenicized charge is then emptied onto the horn scoop ready for mixing with the other ingredients.

The method of procedure is as follows: Weigh out 100 mg of the ores, if needed arsenicise, if not mix directly with 50 mg of borax and 15 mg of soda, otherwise after arsenicising; wrap in soda paper, and reduce on charcoal until melted down, and metal collected in one button.

Now use oxidizing flame, and remove, first, the iron by continued oxidation in presence of fused borax. As long as iron is present the slag will show a distinct green coloration, and on allowing the button to cool it will show a black surface due to an oxidation product of iron and arsenic, probably a basic compound. If much iron is present the treatment with fused borax must be repeated, similar to the treatment of copper with boric acid. When nearly all the iron is gone the little globule of metal on cooling will be covered with iron oxide.

At last the metal button will show a metallic appearance. It is then removed, and after freeing it from the adhering slag, the button is placed on the charcoal without borax and treated with the reducing flame until no more arsenic is given off. The button is then free from iron and is weighed. One hundred mg-weight of button will give the amount of $Fe_2As_2$.

The residual button is again treated with borax in the oxidizing flame. The slag now will show the cobalt-blue coloration. The button on cooling shows a pinkish iridescence. If much cobalt is present the treatment with borax must be repeated by removing the button each time, immersing in water and rubbing clean of slag, and then placing on charcoal with fresh borax.

As the operation nears completion and the cobalt is nearly all eliminated, the pinkish color of the button disappears, the button is harder to keep melted.

When, on pinching some of the pasty slag between the platinum forceps and raising it slowly, it shows a purple color, and the button on cooling shows an apple-green tinge after all the cobalt is out. The button is cleaned and weighed. Then (100 mg — $Fe\ As_2$) — weight of button will give amount of $Ni_2As$.

If last weight is all Ni then the operation is completed, the weight of the button being then $Ni_2As$. But if the nickel left also contains copper, gold and silver then it is best to proceed as follows: Melt the button with about an equal amount of test-lead, and treat it with boric acid as in copper. The nickel is oxidized simultaneously with the lead with little or no loss. When the button shows the characteristics of a copper assay, it is weighed giving the weight of copper, gold, and silver. From here on the operation is similar to the assay of copper, gold, and silver alloys.

*Precautions.*—In heating always aim to have the slag in a melted condition, by melting button and then keeping the flame in the immediate neighborhood of it on the slag. It is far better for the novice to make a small cavity in the charcoal and to melt down in it, as it needs considerable skill to do the oxidizing on the surface of the coal directly. The button has a tendency to roll along the edge of the slag and unless carefully watched will roll off if not in a cavity.

The compounds formed and weighed are the following:

$Fe_3AS_2$ .................. 52.8% Fe
$Co_2AS$ ..................... 61.1% Co
$Ni_2As$ ..................... 61% Ni
$(Cu + Ag + Au) — (Ag + Au) = Cu$
$(Ag + Au) — Au = Ag$
= % Ag
100 mg — Weight of Co, Ni, etc., button $Fe_3As_2 \times 0.528$ = % Fe.
A mg — " " Ni, etc., " $Co_2As \times 0.611$ = % Co
B mg — " " (Cu + Ag + Au)
button $Ni_2As \times 0.610$ = % Ni
(Cu + Ag + Au) — Ag + Au = % Cu
(Ag + Au) — Au = % Ag

The example used is the most complicated one, including six metals.

If there was no iron present the first button obtained would be metallic in appearance and the slag would in all probability show slight losses of the metal present. A blue tinge would show cobalt and a smoky-brown tinge would show nickel. Great care should be exerted by the first melting down, to use a pure reducing flame so as to diminish possible loss. The color of the button is also a reliable source for judging what metal is on hand, pink indicating cobalt, white nickel.

### Mercury Assay

The assay of mercury is very simple. 0.5 gm of the ore is weighed out, mixed with 1 gm of litharge and carefully brush into a glass tube about 19 cm long and 6 mm diam. This glass tube must be closed at one end and bent, as shown in Fig. 8C.

The glass tube is best prepared as follows: Take a glass tube about double the length required. Heat at the middle and draw out. The drawn ends will have a pointed appearance (Fig. 8A) and must be further heated and rounded off as Fig. 8B shows. One of the straight closed tubes is now bent about 2 3 back from the open end, by heating the desired place in a luminous flame while rotating the tube slowly. After a while the glass softens and the tube is readily bent to the desired angle. To prevent cracking it is well to keep the heated portion covered with the soot of the flame until cold.

Before putting the charge in the tube it must be heated so as to drive out the moisture, and prevent the charge from sticking in the straight part of the glass tube. The charge is best put into the tube by folding a card or slip of paper lengthwise, putting the sample on it and shaking it carefully into the tube. Do not forget to brush the card free from any adhering particles. If some of the charge should stick to the tube a small camel's hair brush will serve to remove the particles. The actual charge is then followed by a good layer of litharge.

When the tube is ready for heating, the straight part of it should be absolutely clean. A loosely rolled piece of filter-paper placed on the mouth of the tube will take up any moisture from the charge. The closed end of the tube is then carefully heated. Slowly at first, because there may be moisture in the charge which on rapid heating would blow the litharge out of the bent into the straight part of the glass tube and spoil the assay. When all the moisture is out, the sample is heated until the charge is melted. The mercury will have sublimed and collected in metallic form in the straight part of the tube.

Allow to cool and take care to hold the straight part horizontally so that no mercury is lost. Cut the tube with a file just at the bend, place on anvil and break off the part containing the charge. It is well at this stage to place a small porcelain dish under the open end of the tube, so as to collect any mercury, if it should roll out. When the bent end has been carefully removed, tilt the glass tube over the porcelain dish and with a camel's hair brush attached to a stick or piece of glass rod, brush the mercury into same. Before removing the brush, tap it sharply several times so as to cause any mercury sticking to it to fall into the dish. The globule of mercury should be clean and free from any litharge. It is then weighed, and gives the amount of mercury in the ore.

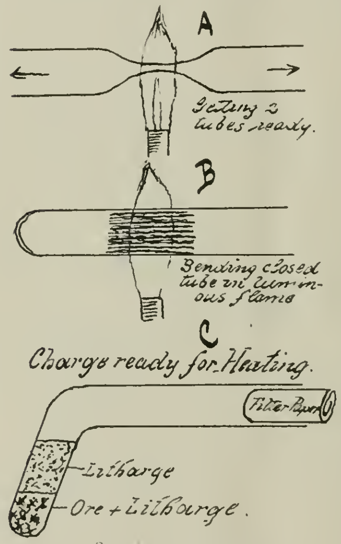

A
Getting 2 tubes ready.
B
Bending closed tube in luminous flame
C
Charge ready for Heating.
Filter Paper
Litharge
Ore + Litharge.

FIG. 8—ASSAY OF MERCURY

It is best to weigh the mercury wrapped in a weighed piece of paper to prevent it from amalgamating with the metal of the scale pan. This method may be used for all sulphide ores containing mercury, with one exception, namely, idrialite, a mixture of cinnabar, clay, gypsum, pyrites and bituminous matter which gives off volatile matter contaminating the mercury.

For chlorides the same charge is used with an addition of soda, the amount of this ingredient being three times that of the ore. The method of procedure is then the same.

### Conclusion

There are further quantitative determinations possible, such as tin and lead, but these lack the certainty that those mentioned possess, and for this reason I will simply refer the reader to the book offering the best information on this kind of work: Plattner's Manual of Qualitative and Quantitative Analysis with the

Blowpipe, translated by Henry B. Cornwall and published by D. Van Nostrand Co., New York City.

It is of interest to know that by the aid of the blowpipe moisture determinations may be made as well as approximate coal analysis. These are, however, of less use to the prospector. To the jeweler quantitative blowpiping may be of use in determining the composition of alloys. But the main use of quantitative blowpipe work lies in the field of prospecting, as it is a quick and simple means of obtaining results, saving both money and time.

Finally I will cite a few examples showing the accuracy of the different methods. These results have been obtained by different individuals on the same ores.

| | | | |
|---|---|---|---|
| *Very rich silver ore, difficult to run:* | | | |
| Ag ............ 2.43 mg | | | worked in 1902 |
| Ag ............ 2.43 " | | | " " 1903 |
| Ag ............ 2.45 " | | | " " 1903 |
| Ag ............ 2.43 " | | | " " 1904 |
| Ag ............ 2.44 " | | | " " 1911 |
| *Gold, silver and copper assay:* | | | |
| Cu ........ 22.0 | Ag ........ 24.2 | Au ........ 53.8 | " " 1906 |
| Cu ........ 22.0 | Ag ........ 24.2 | Au ........ 53.8 | " " 1912 |
| *Iron, cobalt and nickel:* | | | |
| *Chloanthite:* | | | |
| Co ........ 10.8 | Ni ........ 13.2 | | " " 1910 |
| Co ........ 10.8 | Ni ........ 13.5 | | " " 1910 |
| *Garnierite ore:* | | | |
| Ni ............ 6.1% | | | " " 1896 |
| Ni ............ 6.0 | | | " " 1902 |
| Ni ............ 6.1 | | | " " 1914 |
| *Arsenic Speiss:* | | | |
| $Fe_3As_2$ ........ 38.0 | Co ........ 7.9 | Ni ........ 7.7 | " " 1911 |
| $Fe_3As_2$ ........ 36.9 | Co ........ 8.0 | Ni ........ 7.6 | " " 1911 |
| $Fe_3As_2$ ........ — | Co ........ 7.9 | Ni ........ 7.6 | " " 1914 |

The inaccuracies here are not so much due to the method as to the lack of experience of the student, although in the determination of the iron there will always be more or less variation due to possible chances of losses in the operation.

| | |
|---|---|
| *Quartzose Cuprite and Bornite:* | |
| Cu ................ 30.0% | worked in 1901 |
| Cu ................ 30.0 | " " 1903 |
| Cu ................ 30.0 | " " 1905 |
| *Azurite:* | |
| Cu (electrolytic) ................ 48.2% | |
| Cu (blowpipe) ................ 48.1 | |
| *Cinnabar from Malay Peninsula:* | |
| Hg ................ 51.8% | " " 1911 |
| Hg ................ 52.0 | " " 1911 |
| Hg ................ 52.3 | " " 1914 |

The most accurate results are obtained with the gold, silver and copper assays. For the others, especially iron, cobalt and nickel much more practice is required. Considering the amount of work the average prospector has done by the assayer to obtain information as to the possible value of his ores, one can readily observe that the time spent in acquiring these methods of procedure will soon pay, as the results are certainly close enough to give him positive information on the practical value of his ore—and that is what he is after.

Metallurgical Department,
Lehigh University, So. Bethlehem, Pa.

---

**The Ohio Copper Company** is in the hands of receivers as a result of voluntary and involuntary petetions in bankruptcy. The mine and mill near Salt Lake City are closed. Mr. F. Augustus Heinze, one of the principal holders of stock and bonds of the company, has protested against the proceedings on the part of the management, and has asked that the bankruptcy adjudication be vacated.

**The first unit** of the new mill of the Alaska Gold Mines Co., near Juneau, Alaska, is expected to be in operation in December, according to a statement attributed to D. C. Jackling, who has recently returned from a trip to the property. The rated capacity of the mill is 6000 tons per day, but it is stated that alterations in the original plans will make it possible to exceed this by one-third or more. It is expected that the entire plant will be in operation by the middle of 1915.

# An Electrical Process for Detarring Gas*

BY F. W. STEERE

The object of this paper is to give a brief outline of the development of a commercial process for the precipitation of suspended particles from gas by high-tension alternating current, and the practical application of this process to the removal of tar from coal gas and from producer gas.

As the early experiments with high-tension discharges for precipitating suspended matter from gases have been reviewed quite thoroughly in recent articles by Prof. W. W. Strong, Dr. Cottrell, and others, only a brief mention of them will be made here. The phenomenon seems to have been first discovered as early as 1825, but very little, if any, effort was made to make practical use of it. From the first the precipitation of smoke seems for the most part to have claimed the attention of experimenters. The possibilities of separating gold, silver, and other metals carried in smelter fumes in a finely divided state, and the precipitation of acid fumes from smelters have also been fertile fields for inventors for years, the first patents having been issued as early as 1886.

The question is naturally asked why this method of purifying gases has not long since been in commercial use. Possibly the answer is found in the fact that although the phenomenon may be readly demonstrated on a laboratory scale with very simple apparatus, many serious difficulties were encountered in the various attempts to develop commercial apparatus embodying the same principles, but capable of continuous operation with little attention. A beautiful demonstration may be given with a hand-operated static discharging in a glass cylinder, or, on a larger scale, with an X-ray outfit discharging from wires suspended in ordinary piping, etc.

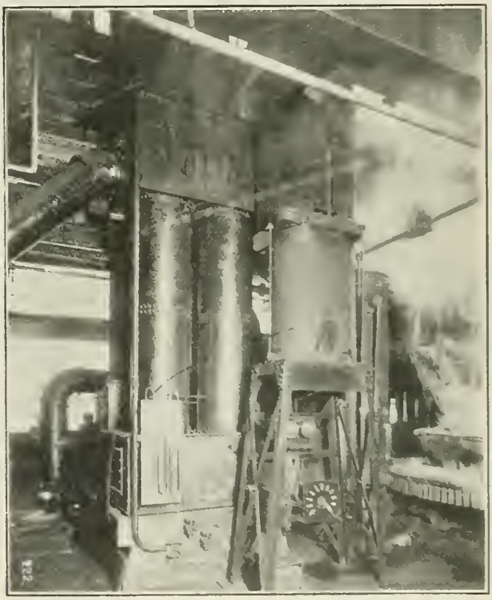


FIG. 1—ELECTRIC DETARRING APPARATUS FOR COKE OVEN GAS AT THE DETROIT PLANT OF THE SEMET SOLVAY CO.

---

*A paper read before the American Gas Institute (New York meeting, October, 1914). Copyright, 1914, by American Gas Institute. Subject to Author's Corrections.

Such work, however, is hardly the first step towards the solution of the problem of a complete installation doing service and earning dividends 365 days in the year under the conditions found, for instance, in the ordinary gas plant.

The process recently developed by Dr. Cottrell shows what can be accomplished in precipitating dust. The Cottrell process consists in rectifying high-tension alternating current on rotating switches driven by synchronous motors, giving an intermittent unidirectional discharge. A plant using this process has recently been completed for precipitating the dust from the cement works of the Riverside Portland Cement Company, Crestmore, Cal., and acording to recent reports is giving excellent results.

Herbert A. Humphrey seems to have been the first to use high-tension electric discharges to precipitate tar. Prior to 1897 we learn that Mr. Humphrey was using a static discharge within a small glass vessel through which he passed a known volume of gas, for making quantitative determinations of the tarry matter carried by the gas.

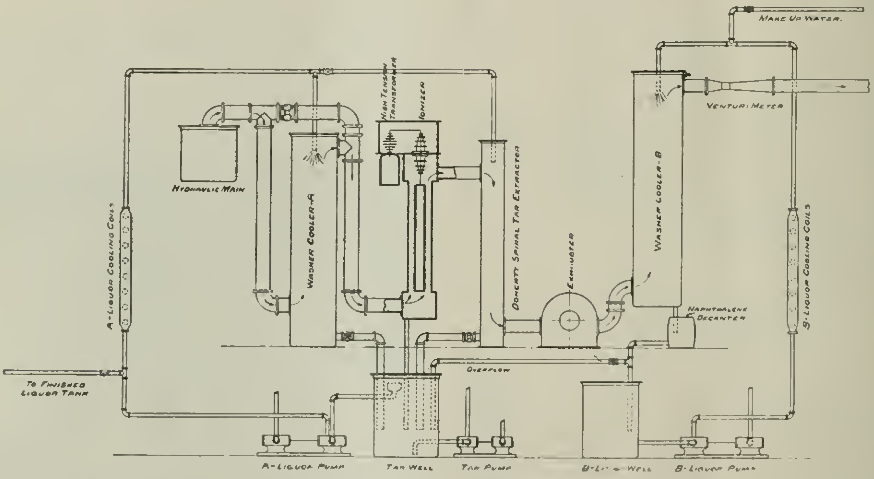


FIG. 2—DIAGRAMMATIC SKETCH OF THE EXPERIMENTAL PLANT FOR THE ELECTRICAL DETARRING OF COKE OVEN GAS AT THE DETROIT PLANT OF THE SEMET SOLVAY CO.

In 1911 work was started along these lines in the research laboratories of the University of Michigan at the suggestion of Prof. A. F. White. This work consisted for the most part in repeating the experiments of the early investigators and in attempting to apply the Cottrell process to the precipitation of tar from coal gas. The results of these preliminary investigations were given to the gas fraternity in a paper entitled "The Electrical Separation of Tar from Coal Gas," by A. F. White, J. W. Hacker, F. W. Steere, which appears in the *Proceedings* of the Michigan Gas Association for 1912.

The author, while engaged in this research work at the University of Michigan, became convinced that with a suitable arrangement of electrodes and apparatus, alternating current might be used instead of rectified current. The complications and difficulties of rectifying alternating current of from 40,000 volts to 80,000 volts on synchronous-motor-driven rotating switches will be readily appreciated. No gas man would relish the idea of having such an outfit as a part of his plant equipment to be looked after by the average operator, especially in those states having workmen's compensation laws.

By the use of alternating current the synchronous motors and rotating switches would be eliminated as well as the leads carrying the high-tension current from the transformer to the rectifier and from the rectifier to the electrode connections. Further, with the simple use of alternating current the transformer may be mounted on the ionizer, one terminal may be grounded and the other connected directly to the electrode terminal. With the terminals and connections completely inclosed so that no high-tension parts would be exposed, and with no moving parts requiring attention or inspection, the element of danger would be absolutely eliminated.

An opportunity was provided at the Detroit plant of the Semet-Solvay Company to work out these ideas and develop the theory on which this work is based. This theory, although far from complete, has proven sufficiently accurate to guide us in perfecting a detarring process which is in commercial use to-day.

In attempting to briefly outline the electrical action, we must keep in mind, first, that the gas molecules themselves possess both positive and negative electrical constituents which can be separated by X-rays, beta and gamma rays of radium, brush discharge from points, corona discharge from wires raised to high potential, ultra-violet light, etc. This process of separating neutral gas molecules into electrically charged parts or ions is called "ionization." It is outside the scope of this paper to attempt to discuss the ionic theory, but it should be noted that ions as such are very unstable and cease to exist, that is, recombine to form neutral molecules, almost the instant they are outside the ionizing influence. A very few molecules are continually splitting up, presumably because of the trace of radio-active substances found in most gases as well as in the atmosphere.

Professor Millikan, of the University of Chicago, has studied the movements of a small drop of oil between two oppositely charged condenser plates when attacked by atmospheric ions.* The drop received a charge when atomized, so by throwing on and off the electrical field, the drop is made to beat up and down between the plates. The instant an ion attaches itself to the drop the fact is made known to the observer by its change in speed, this change depending on the sign of the ion and the charge on the drop. The important and interesting thing to note is that with over a thousand drops studied in this way, the change of speed was always exactly proportional to the number of ions attached to the drop.

---

* "The Oil Drop Method of Studying Electrical Phenomena in Gases," R. A. Millikan, *Trans.* American Electrochemical Society, Vol. XXI, 1912.

Let us recall that there were about twenty-seven billion molecules in 1 c c of ordinary air and that each molecule may be separated into at least two ions. When just one of the possible fifty-four billions ions per cubic centimeter attached itself to the oil drop it instantly caused an appreciable change in its velocity. Imagine then the violence with which this drop would have been thrown about if all the molecules surrounding it had been ionized.

This is just the condition we bring about in the electrical detarrer. The gas carrying the minute tar globules is swept into an intense ionizing field. Billions of gas molecules on every side are being torn apart. The resulting ions rush madly about in their effort to recombine. The unsuspecting tar globules find themselves in a storm center of unseen forces hurling them in every direction. The time occupied in the passage of the tar particles through the electric field is brief and it might naturally be supposed, as it herefore has been, that an aimless to-and-fro movement of them would be the result of the applied energy. It would be hard to conceive of a condition more favorable to impact between tar particles, and experience shows that either because of this impact, or for some reason as yet unknown, agglomeration results and the dense tar mist is almost entirely dissipated leaving a relatively few large tar drops in its place.

This rather figurative description will seem more real to those who have witnessed this remarkable phenomenon within a glass vessel filled with dense fumes or fog. The instant the current is turned on, the whole field can be seen to clarify. The commercial importance of this becomes more apparent when we realize that this action can be brought about at almost any desired temperature.

No attempt is made to free the gas of these agglomerated tar particles while it is still in the ionizing field. The apparatus is so arranged that everything is swept on through into some form of mechanical extractor where a complete removal is effected with very little power loss. The Doherty centrifugal tar extractor worked very well to accomplish this; the old type P and A machine also became a very efficient tar extractor when placed after the ionizer.

The whole process may be summed up in this: It is practically impossible to free the gas from tar in the extremely fine state of subdivision which naturally results from rapid condensation. There is no difficulty in removing relatively large drops, and the electrical treatment simply converts the fine mist into the large drops.

A diagrammatic sketch of the experimental plant built at the Detroit Coke Ovens is shown in Fig. 2. The plant was not built complete as shown here at first, but was added to and altered as the work progressed. The course of the gas may be readily seen by referring to the cut. From the hydrauic main the gas passes either to a small washer-cooler *A* or by-passed this directly to the ionizer, depending on the temperature desired for the test. After the ionizer came the mechanical extractor, of which various types were tried. This apparatus was all on the suction side of the motor-driven exhauster Following the exhauster was a second washer-cooler *B*, where the final cooling was effected. Measurements of the gas volume were made with a Venturi meter. The capacity of the plant was about 30,000 cu. ft. of gas per hour.

All work was done on the rich gas, that is, the gas given off during the first six or eight hours of the coking period. To insure complete recovery of ammonia and in other respects to duplicate as far as possible the condensing system used at the Detroit coke oven plant, two sets of cooling coils were used, one for cooling the circulating liquor from washer-cooler *A* and from the mechanical extractor when liquor was circulated through it, and one set for the circulating liquor from washer-cooler *B*. The make-up water was added to the *B* system and overflowed to the *A* system. When the *A* liquor was up to strength, it was pumped to the weak liquor storage tank.

Extensive use was made of the filter paper method of studying the condensed matter carried by the gas. This consists of aspiring a known quantity of gas through two thicknesses of filter paper, the resulting stain indicating relatively the quantity and to some extent the quality of the suspended matter. With the ordinary methods of condensing and cleaning, quantitative determinations by this method are unreliable, especially with producer gas, as an appreciable quantity of the very fine tar mist will pass readily through two thicknesses of filter paper. When the gas carries large quantities of tar mist, the aspirator bottle will be full of the dense brown fog which has passed through the papers. Over 1200 of these tests were taken in the course of this work and, although practically white papers were taken, we believe we have more reliable and conclusive evidence of the completeness of the detarring, which will be mentioned later.

The best results were obtained with the gas entering the ionizer at a temperature of from 65 deg. to 80 deg. C. (149 deg. to 176 deg. Fahr.). There was every indication, however, that with a gas not saturated with water vapor, the electrical action would be fully as effective at very much higher temperatures. Since this action is purely electro-mechanical in so far as it affects the tar,

FIG. 3—LARGE GAS ENGINE AT FORD WORKS, OPERATED BY ELECTRICALLY DETARRED PRODUCER GAS

the higher the temperature of ionization the more condensate will come down with the subsequent cooling. If the lower temperature condensate proved troublesome, a second treatment at a lower temperature could be used.

A very interesting development was the effect on the gasman's old enemy, naphthalene. Naphthalene by itself in the gas works, is quite a harmless and possibly valuable by-product. The trouble is all in the company it keeps; when mixed with enough tar to act as a binder, it is exceedingly troublesome, but when the tar is removed before the naphthalene condenses in appreciable quantities, the real cause of the trouble is eliminated.

This segregation was brought about as follows: Washer-cooler *B* was sealed in a barrel through a 3-in. pipe. The circulating liquor was drawn from the bottom of this barrel, cooled in pipe coils and returned to the top of the apparatus. It was found that with the foul gas entering the ionizer at about 70 deg. C. (158 deg. Fahr.) the naphthalene vapor was condensed in washer-cooler *B*, where the gas was cooled, and the crystals were carried out of the apparatus through the 3-in. pipe with the liquor into the seal barrel, and immediately came to the surface. The separation of the crystals and liquor even in this small vessel was almost perfect. After several weeks' run there was not the slightest indication of any deposit in the cooling coils or liquor lines. The gas was cooled in washer-cooler *B* to from 16 deg. C. to 25 deg. C. (60 deg. to 77 deg. Fahr.). Picric acid tests which were run to determine the naphthalene carried by the washed and cooled gas, checked invariably with the tables giving the theoretical naphthalene saturation at the observed temperature.

The whiteness of the naphthalene crystals recovered and the fact that there was absolutely no indication of any deposit in the coils or pipe lines, we consider proof conclusive of the complete freedom from tar.

Although at present naphthalene is a drug on the market it possesses so many of the characteristics of an ideal fuel for certain power purposes we are confident that it will become an important factor when there is a sufficient and dependable supply available. The farm tractor seems to offer an attractive field for investigation along these lines, especially in view of the success with which naphthalene is being used as an internal-combustion engine fuel abroad.

The two most valuable constituents of commercial light oil are benzol and toluol. The absorbing power of tar for these oils increases as the temperature decreases. With the tar as a fine mist the surface of contact between the tar and condensable hydrocarbon vapors is a maximum. It follows theoretically that if the tar mist is agglomerated to larger particles at relatively high temperatures the tendency for these oils to become absorbed by the tar is greatly reduced, and if this is followed immediately by a complete removal of the tar, this absorption of light oil by tar is reduced to a minimum.

Considerable work was done along these lines which undoubtedly establishes this theory within the range of our observations. Unfortunately we were unable to get gas above 80 deg. C. (176 deg. Fahr.), entering the ionizer, but analysis showed that the tar precipitated with the gas entering the ionizer at this temperature, contained but a trace of light oil, while the gas tested simultaneously, showed the highest light oil content. Light oil is, of course, not made by this process, but these experiments have shown beyond a reasonable doubt that the percentage of light oil carried by the gas and hence its illuminating power can be very materially increased. In coke-oven practice this has a distinct commercial importance with the increasing value of benzol as a motor fuel, and of toluol for use in the manufacture of explosives.

Cleaning producer gas for use in gas engines is one of the later developments of this process. Producer gas tar is very much more pitchy than coke-oven tar and the tar mist particles hardened at very much higher temperature. The tar mist carried by this gas when rapidly condensed, as is necessary in a compact plant, was found to be in such an extremely fine state of subdivision that a large per cent of the tar passed readily through two thicknesses of filter paper. It is this extreme fineness and relative hardness of the tar particles which makes the complete cleaning of producer gas by purely mechanical means a physical impossibility without an excessive power loss.

Arrangements were made with the Ford Motor Company, of Detroit, to try this process on the producer gas driving their large gas engines. At the outset many unlooked-for difficulties were encountered which required considerable time and study to overcome. Had it not been for the sportsmanlike attitude shown by Mr. Edward Gray, chief engineer and designer of the engines, in giving us every opportunity to study out these problems, we might have a very different report to make at this time.

The electrical process was eventually put in run at the Ford plant on Jan. 21, 1914, and up to this date has not been out of service one minute while the plant was running. All the difficulties which were in any way way due to tar have been entirely eliminated. The regular operating force start up and stop the process with perfect confidence and at no time has it required any special attention.

In conclusion I wish to again call attention to the fact that this method of attack goes to the source of all the difficulties, that is, the almost molecular fineness of the tar particles which persist in carrying along with the gas in defiance of all mechanical scrubbers and washers. An enormous amount of time and study has been required to bring this process to its present stage, but notwithstanding the various difficulties, we now have in commercial operation a plant which requires no attention, is self-cleaning and is started or stopped at will by the regular operators.

The value of this electrical detarring process to the illuminating gas industry is as yet problematic, but it presents some very interesting possibilities. Its adoption would make possible a somewhat higher illuminating power with a given gas than is obtained from the same gas when the tar is removed in the usual way. By its use followed by a washer-cooler, tar-free naphthalene can be condensed and removed from the gas without causing stoppages in the condensing apparatus. The tar can be completely removed from the gas at any desired point in the gas condensing and scrubbing system; the complete removal of tar, prior to condensing gas, will make a relatively clean weak liquor possible. For the by-product coke-oven industry the process promises to be of value in connection with the direct method for the manufacture of ammonium sulphate, as well as for its possibilities as a means for recovering naphthalene and increasing the yield of benzol and tuluol.

The commercial plant for detarring producer gas which has now been in continuous and successful service at the Ford Motor Company for several months has demonstrated beyond all doubt the value of the process for this branch of the industry. With these possibilities it seems not unlikely that this process may eventually play an important part not only in cleaning producer gas, but also in the manufacture of coal gas.

Detroit, Mich

# Note on the Preparation of Pure Calcium Carbide

BY M. DEKAY THOMPSON
EXPERIMENTS BY L. R. GONZALEZ AND K. B. BLAKE

In the reaction according to which calcium carbide is prepared technically, $CaO + 3 C = CaC_2 + CO$, the carbide is necessarily contaminated by the presence of lime and carbon, and it is not possible to remove these impurities.

A number of methods of making calcium carbide in the pure state have been described, but in attempting to follow directions for the purpose of making pure calcium carbide for experimental purposes, difficulties were encountered which were not mentioned in the papers describing these methods. Our experience with the different methods that looked promising are given below.

### THE ACTION OF PURE CARBON ON METALLIC CALCIUM

The first method tried for producing pure calcium carbide is the action of calcium on finely divided carbon, as described by Moissan[1]. According to Moissan this synthesis takes place at a low temperature and can be produced by heating a mixture of carbon and calcium in a porcelain crucible over an alcohol lamp. The heat evolved fused the carbide.

The calcium used in our experiments was furnished in the form of a rod about two inches in diameter, and was evidently made by the Rathenau[2] process.

Turnings were made from this rod in a lathe, keeping the metal covered with a film of kerosene during the operation. The turnings were kept under petroleum ether. It was analyzed by dissolving a weighed portion in water and titrating with standard hydrochloric acid, using methyl orange as an indicator. Any sodium or magnesium present would be counted as calcium. Magnesium and iron were shown to be absent. The purity found by this method was 98.17 ± 0.01 per cent.

Carbon was prepared in three different ways. (1) Sugar was added to sulfuric acid, causing carbon to separate in a spongy mass. Some sulfuric acid was reduced to sulfur dioxide, which was recognized by the odor. The mass was washed, dried, ground up, and boiled in caustic potash for several hours, and then in successive portions of water until the sulfate was entirely removed. This was then dried and ignited at a dull red temperature for one hour.

(2) Carbon was made by allowing acetylene to burn with a smoky flame and the soot collected on a copper vessel filled with water. Acetylene was generated from commercial calcium carbide and was purified[3] by passing in succession through a concentrated solution of chromic acid in sulfuric acid, a saturated solution of lead nitrate, and finally through a drying tower containing a layer of bleaching powder below a layer of calcium chloride. Ten grams of carbon were prepared by this method, which after igniting had a bluish tinge.

(3) The third method consisted in burning granulated sugar, grinding to powder and washing free from caramel. This was dried and ignited at a dull red temperature for half an hour in a covered porcelain crucible. This product had a shiny black color.

Equivalent quantities of calcium turnings and carbon made from sugar and sulfuric acid (2.156 gr. Ca, 1.275 gr. C.) were mixed in a porcelain crucible. The crucible was heated by a Tirrell burner for five minutes, but the desired reaction did not take place. The calcium had oxidized. Another similar sample of calcium and carbon was heated in the blast lamp. After two minutes the reaction took place with violence, breaking the crucible. The contents were incandescent. Two portions of carbide were made in this way. It was of a greyish brown color and was hard and porous. The part in contact with the crucible was not collected. The rest was analyzed by the loss in weight method of Bamberger[4]. It was found to be 62 per cent. carbide. On boiling the sodium chloride solution in which the carbide was decomposed, after the addition of a little caustic soda, a strong odor of ammonia was noticed, showing that at the high temperature of the reaction, some calcium nitride had been formed.

Evidently, therefore, pure calcium carbide in any appreciable quantity cannot be produced by the direct action of carbon and calcium.

### THE ACTION OF CARBON ON CALCIUM HYDRIDE

The production of calcium carbide by the action of carbon on calcium hydride is also described very briefly by Moissan. The hydride was made by heating calcium turnings in an atmosphere of hydrogen in a nickel boat in an electric tube furnace. Ten grams of calcium was the largest amount used at one time[5]. The absorption of hydrogen by calcium started from 220° C. to 250° C. The temperature was gradually raised to 900° C., and held there until no more hydrogen was absorbed.

Eight separate portions of hydride were made; the first was pure white; the others were grey. In some cases the calcium alloyed with the nickel boat and had to be discarded. The hydride was crystalline and easily powdered. It was ground up and thoroughly mixed with an equivalent weight of carbon made from sugar and sulfuric acid. This was heated in the electric tube furnace.

The reaction which takes place is the following: $CaH_2 + 2C = CaC_2 + H_2$. The hydrogen was removed by a Richards pump and the pressure kept at about seven millimeters of mercury. The product obtained after several trials appeared white to the naked eye. When examined under the microscope the main part was seen to be white and transparent, except for crevices between the crystals which were apparently filled with uncombined carbon.

The analysis gave 103 per cent carbide. The cause of the apparent excess was found to be the presence of hydrogen sulfide, which was weighed as acetylene. The sulfur doubtless came from the sulfuric acid used for carbonizing the sugar. This shows how difficult it is to remove all the sulfur from carbon made in this way. Probably some of the acid is reduced to sulfur by its action on sugar.

The reaction between the hydride of calcium and carbon appears to begin at 50° C. as shown by the evolution of gas, which becomes rapid between 110° and 125°. This may, in part, be occluded gases of the carbon. The reaction appeared to be complete at 940° C.

The action of carbon made from acetylene on calcium hydride was next tried. The hydride was ground and passed through a sieve with 140 meshes per linear inch; 11.07 grams of this hydride were mixed with 6.292 grams of carbon by grinding the two together. One-third of this mixture was taken for a charge. This was placed in a nickel boat and heated in the tube furnace. The air was washed out by hydrogen before heating. On heating this mixture evolution of gas began at 30° as in previous runs, and continued as the furnace was heated to 1200°. (This was the temperature at the middle of the furnace; the ends of the boat may have been one hundred degrees cooler.) Even after holding the temperature at 1200° for an hour the evolution of gas still continued.

---

[1] C. R. 127, 917-18 (1898).
[2] Z. f. Elektroch. 10, 508 (1904).
[3] Thorpe, Dic. of App. Chem., Vol. 1, p. 25 (1912).
[4] Z. f. angew. Ch., 1898, 196.
[5] Moissan gives 15 grams as the upper limit. More metal may cause the temperature to rise to be sufficient to alloy the calcium and nickel. C. R., 127, 29 (1898)

The furnace was cooled without waiting for the gas evolution to be complete, and the charge examined. Except for a discoloration, the charge appeared unchanged; it did not react with water, and under the microscope the crystals of hydride could be seen, surrounded with the finer carbon. This showed that for some unexplained reason the carbon from acetylene does not react with calcium hydride to form calcium carbide.

The evolution of gas must be explained some other way. It may have been gas that was occluded in the carbon to start with or possibly the subcarbide[6] of calcium may have been formed: $CaH_2 + C = CaC + H_2$. The subcarbide does not react with water, but still this explanation does not seem probable.

The action of carbon made by heating sugar was also tried on calcium hydride. When mixed in equivalent quantities and heated in an electric tube furnace to 1000° C. in a vacuum, the product contained 28 per cent carbide. With a more intimate mixture the product contained 41.3 per cent carbide.

Pure calcium carbide cannot therefore be made in quantity by the action of carbon on calcium hydride.

### THE ACTION OF ACETYLENE ON CALCIUM AND CALCIUM HYDRIDE

When fine turnings of calcium were exposed to acetylene gas in a porcelain tube furnace at a temperature as high as 750° C., carbide was produced only on the surface of the turnings. The action of acetylene on calcium hydride was even less than on calcium.

### THE ACTION OF ACETYLENE ON CALCIUM DISSOLVED IN LIQUID AMMONIA

Finally Moissan's method[7] of passing acetylene into a solution of calcium in anhydrous liquid ammonia was tried. On passing acetylene into the blue solution the white precipitate described by Moissan consisting of $CaC_2 . C_2H_2 . 4NH_3$ appears and the solution loses its color. More calcium is then added and this may be continued until the required amount of carbide is obtained. (If the calcium is added to liquid ammonia in larger quantities a lustrous golden brown paste is formed.)

This carbide, however, is very reactive, due to its fine division, and the moisture of the air acts on it with such violence that the acetylene produced takes fire. According to Moissan the acetylene and ammonia are driven off at 150° C.

This method of preparing pure calcium carbide is, therefore, the only one of those tried that seems suitable for yielding it in sufficient quantity for experimental purposes. There is no difficulty in handling it as long as it is moist with ammonia. In introducing it into an electric vacuum furnace, for example, it would be necessary to have it covered with ammonia.

Some of the paste made by dissolving a large amount of calcium in liquid ammonia was allowed to stand in an atmosphere of acetylene. It gradually changed over into a grey powder which did not take fire in the air, and could be transferred to the furnace without any protection.

When heated to 150° it yielded a fine white powder, which when it was treated with water evolved an odorless gas.

### SUMMARY

Experiments are described, the object of which was to find a suitable method for making pure calcium carbide in quantities large enough for experimental purposes. The reactions between the following substances were not found to be suitable: carbon and calcium; carbon and calcium hydride; calcium and acetylene; calcium hydride and acetylene. The action of acetylene on calcium dissolved in anhydrous liquid ammonia was found to produce the desired result.

Electrochemical Laboratory,
Massachusetts Institute of Technology.

---

[6] Erlwein, Wart, and Beutner, Z. f. Elek. 17, 177 (1911).

[7] C. R. 127, 911-17 (1898).

---

## Radium for the Masses

A Western assayer and chemist has received an important document from a genius whose letter-head announces that he is a dealer in "Dry Goods, Groceries, Hardware, Queensware." Evidently his activities are broader than indicated by his business, and scientific ability is being wasted in dry commercial pursuits. We quote *verbatim* from the letter:

> Dear Sir,
> I wish to take up small amount of your time to inform I have way to extract Radium from carnotite ore and get more out of it than heretofor.
> If your in position to send me 5 or 10 pounds of your ore from your state I will extract it and send you the Radium free of cost I want to find how rich your ore is by that way hoping to her of you.
>
> Yours Respectfully

Let the Bureau of Mines look to its laurels!

---

**Laboratory Apparatus and Reagents Catalog.**—The Arthur H. Thomas Company, of Philadelphia, Pa., has just issued its handsome new catalog entitled Laboratory Apparatus and Reagents, selected for laboratories of chemistry and biology in their application to education, the industries, medicine and the public health, including some equipment for metallurgy, mineralogy, the testing of materials and optical projection. It is a handbook of 660 pages, and embodies some really important novel features, particularly in the Reagents' Section. The first and by far the largest section deals with laboratory apparatus on 585 pages, brief, concise, illustrated descriptions being given of more than 12,000 different pieces of apparatus. The general arrangement is alphabetical, but in view of the mass of material described, a special alphabetical index of twenty pages at the end of this section is by no means superfluous. The reagents' section is the second section of the catalog and comprises seventy-four pages. In it 2300 different chemicals are listed alphabetically. The outstanding feature is that in the case of the chemically pure chemicals of Baker, Kahlbaum and Merck, the "typical analysis" of Baker, the "certified analysis" of Kahlbaum and the "guaranteed analysis" of Merck are given respectively, which facilitates greatly the selection of the most suitable brand in each case. The prices listed are the prices before the war started, and indicate, at least, the normal price basis for the reagents.

**The Miami Copper Co.** has officially announced the passing of the regular quarterly dividend payable November 16, 1914, due to conditions of the world's business and finance and the necessity of conserving the company's resources. The Boston News Bureau estimates that the passing or reduction of dividends by copper companies has caused a loss to investors at the annual rate of nearly $29,500,000.

**Production in the Cobalt district** increased in September as compared with August, and is now about normal. Temporary curtailment in August was due to uncertainty regarding the silver market caused by the war.

## Synopsis of Recent Chemical and Metallurgical Literature

### Copper, Lead and Zinc

**Electric Furnace for Melting Cathode Copper.**—The adaptability of the electric furnace to melting, refining and finishing purposes, and the disadvantages arising from the use of the reverberatory in melting cathode copper, have led Messrs. **D. A. Lyon** and **R. M. Keeney** to consider the possibility of electric melting of this material. Their original paper appears in the August *Bulletin* of the A. I. M. E. It is shown that so-called reverberatory refining of cathode copper results in deterioration of conductivity as compared with electrolytic copper which has not been melted, due to the introduction of impurities during melting. The ideal method would be one in which cathode copper would be melted and cast into marketable shapes without absorbing impurities. This would require a neutral process of melting such as could be done in an electric furnace. The authors discuss the types of furnace that might be used: (1) induction; (2) resistance; (3) direct arc; and (4) indirect arc. The conclusion is reached that the most practical furnace for copper melting would be the direct-arc type having a non-conducting hearth, like the Heroult steel furnace. In order to reduce possible volatilization to the lowest point it would be necessary to keep the metal covered with a slag while current is passing through the furnace. It is estimated that the power consumption would not be over 300 kw-hr. per ton of copper melted. Using this figure and basing other expenses on electric steel practice, the cost of melting cathode copper in a furnace of 25 tons capacity per charge should not exceed $4.75 per ton, or 0.238 cents per pound, of copper melted, with power at $\frac{1}{2}$ cent per kw-hr.

**Fuel in Reverberatory Copper Smelting.**—A valuable record of experimental work in reverberatory smelting is contained in the paper of **Mr. C. D. Demond** in the August *Bulletin* of the A. I. M. E. Experience with various fuels at Anaconda is given in detail, showing the requirements for a satisfactory reverberatory fuel. Four factors in coal affect smelting efficiency: 1, the character of the true coal substance; 2, the percentage of fine; 3, the percentage of moisture; and 4, the character and percentage of the ash.

In judging the character of the coal from proximate analysis a good deal of caution must be used, for the figures may be very misleading as to the ratio of fixed carbon to volatile matter in the real coal, and nothing can be told regarding the composition and quality of the volatile matter. Coal giving an opaque yellow or white flame due to incandescent particles is essential for success in reverberatory work. An excessively dense or smoky flame is not desirable. With coals that do not flame well under natural draft there may be a marked improvement under forced draft.

Furnace results are directly affected by the quantity of fine in the coal, the ratio of charge smelted to coal burned falling with the increase of fine coal. The best solution of the problem of fine coal is to pulverize all the coal and burn it by blowing directly into the furnace. This practice is growing in favor and has been adopted at some plants.

Moisture in the coal requires heat for its evaporation, and reduces the temperature of the furnace. The percentage reduction of the margin above the critical temperature reduces the capacity and economy of the smelting operation.

Ash also reduces the heating value of the coal, but has a value in preventing excessive loss of fuel through the grates. In some cases, however, the ash may clinker so badly as to clog the grate and interfere with combustion. It is seldom possible to predict from an analysis of the ash what its clinkering qualities will be.

Other factors affecting the efficiency of reverberatory smelting are the fluxing of the charge, preheating the charge and preheating the air. Mixing limerock flux with the calcine before charging to the reverberatory as against charging calcine and flux separately, has resulted in increasing furnace performance from 144 tons smelted with 46 tons of coal to 163 tons smelted with 48 tons of coal. Charging the calcine mixture hot also results in increased economy. Preheating the air in efficient heating devices has resulted in some cases in increasing furnace capacity 50 per cent over that obtained with cold air. The production of steam with waste heat from reverberatories at Anaconda makes about 25 per cent of the heating value of the total coal affective, while only 15 per cent is actually utilized for smelting. Power thus developed from eight furnaces amounts to 30 per cent of the 16,700 mechanical horse power used in the entire smelting and concentrating plant.

**Sinter-Roasting Processes Compared.**—A comparison of the Huntington-Heberlein and Dwight-Lloyd processes for roasting and agglomerating finely divided ores, is given by **Mr. W. W. Norton** in the August *Bulletin* of the A. I. M. E. Both systems of sinter-roasting are installed and in use at the Murray plant of the A. S. & R. Co., of which the author is superintendent. Five points of comparison are considered: cost of installation, cost of roasting, adaptability to wide range of materials, metal losses and physical condition of product. The author finds advantage in favor of the Dwight-Lloyd system on the first and third counts, in favor of the Huntington-Heberlein on the second and fifth, and is doubtful regarding the fourth. He gives results of furnace campaigns that show no advantage to reside in the physical condition of the Dwight-Lloyd product, either as to efficiency in reduction of the charge or speed of smelting. On the other hand he finds the Dwight-Lloyd excellently adapted to flexibility in the charge. No overwhelming advantage is found for either system.

**Recovery of Zinc and Antimony in Lead Refining.**—In the Parkes process for recovering the precious metals from base bullion, zinc is added to the molten lead in order to form an alloy with gold, silver and copper, which is removed by skimming. Antimony, if present, is not removed, and some of the zinc also remains. In order to remove these latter, air is blown through the molten mass, whereupon zinc and antimony oxidize, rise to the surface and are skimmed.

It has been found, also that the recovery of zinc and antimony from the desilverized bullion can be better accomplished in two stages. Zinc oxidizes first, and can thus be concentrated in a first skimming. The temperature is then raised, air is again blown through the bath and a second skimming removed which consists mainly of antimony.

At the Salt Lake meeting of the A. I. M. E., Mr. **Richard D. Divine** described a process for the treatment of this zinc-lead-antimony skimming, consisting in mixing it with sodium carbonate and pulverized oil coke, and heating in a reverberatory furnace on a bath of lead. Antimony and lead in the skimming are reduced and go into the lead bath, while zinc is volatilized as oxide.

The author suggests the possibility of applying the zinc-lead-antimony separation with sodium carbonate and coke, to complex zinc-lead ores after they have been roasted, and states that small-scale experiments seem to indicate a successful solution of the problem.

**Electrostatic Separation at Midvale.**—In Fig. 1 is given a flow-sheet of electrostatic separation of zinc-iron middling produced in the wet concentrator at Midvale, Utah. According to the latest data on this plant, presented by Mr. H. A. Wentwood at the Salt Lake meeting of the A. I. M. E., 1 pound of coal suffices for the evaporation of 5 to 7 pounds of water in drying the wet middling. By reference to the flow-sheet it will be seen that each unit in the separator produces three products: finished iron, finished zinc, and a middling which is returned to the screens. The potential used on the machines is 18,000 to 22,000 volts. One terminal of the potential line is grounded, as also are the machines. The other terminal is connected by highly insulated wire with the so-called attracting electrodes of the separators. An improvement in the machines consists in the substitution of metal for wooden electrodes, resulting in reducing the cost of maintenance 75 per cent.

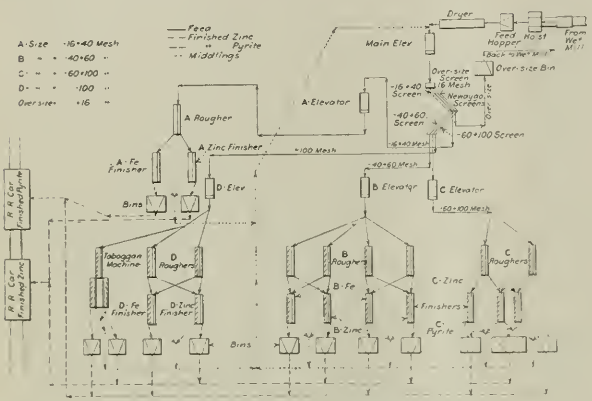


FIG. 1—FLOW SHEET OF ELECTROSTATIC MILL

**Lead Blast-Furnace Bosh.**—Commenting on the fact that blast furnaces frequently run better after they have been in blast for some time, and that furnaces with heavy crusts give remarkably clean slags, Mr. L. D. Anderson suggests that our standard shape of furnace is not ideal. In the November *Bulletin* of the A. I. M. E., Mr. Anderson states, with respect to angle of bosh, that "a rebuilt furnace of only about 10° or 11° has been running beside furnaces of the old angle of over 20°. As far as observed, the new furnace seems to run much hotter and obtain a larger percentage of lead contents as direct bullion output. The matte fall, however, is considerably smaller, and it is necessary to carry more sulphur on the charge in order to maintain this fall high enough to insure clean slags. . . . I feel that the matter of the correct furnace shape is yet far from being settled. Furnaces have been observed with crusts in them so heavy as to make it seem almost imperative to take them out of blast, whose slags nevertheless were so clean as to make the metallurgist reluctant to disturb them, until finally blowing out becomes imperative on account of the reduced tonnage. Experiences of this kind lead to speculations as to whether better reductions might not be obtained by making the shaft walls converging instead of diverging, somewhat after the lines of the iron blast furnace. In other words, why not make the furnace the ideal shape at the outset, instead of waiting for it to form its own 'natural' shape and running all the chances of irregularity in the formation of crusts?"

**Comparison of Huntington-Heberlein and Dwight-Lloyd Sintering Processes.**—In discussing a paper on this subject by W. W. Norton, presented at the Salt Lake meeting of the A. I. M. E., Mr. Arthur S. Dwight gives some interesting data in the November *Bulletin.* In regard to the reducibility of the products of these two methods of sintering, Mr. Dwight states that D-L sinter not only permits of economy of coke, but actually demands it. The fuel on a blast furnace charge must be proportioned to the work of reduction and melting. If some of these functions have been performed before the material enters the furnace, a corresponding allowance must be made if the fuel balance is disturbed. Since the iron in D-L sinter is present mainly as FeO, while in the H-H product it is as $Fe_2O_3$, there is less reduction to be accomplished with D-L sinter, and consequently less coke is required. As to range of sulphur in the charge, D-L machines can handle higher sulphur than the H-H pots. In regard to lead losses in the two processes, Mr. Dwight cites one plant at which the lead loss was 3 per cent in pots and only 0.75 per cent in D-L machines.

In discussing the same subject, Mr. G. C. Riddell states that at the East Helena plant of the A. S. & R. Co., where high lead charges are the rule and both D-L and H-H processes are used, the furnaces run at higher speeds and with lower coke consumption when dominated by the D-L sinter. Cost per unit of sulphur eliminated during 1913 was practically the same for both processes. Metal losses also were equal in both methods. A summary of Murray and East Helena experience with these two processes would appear as follows:

| | Advantage in Favor of | |
|---|---|---|
| | at Murray | at East Helena |
| Cost of installation......... | D-L | D-L |
| Cost of roasting............ | H-H | Even |
| Adaptability of charge .... | D-L | D-L |
| Metal losses ............... | Even | Even |
| Physical condition of product | H-H | D-L |

**Nodulizing Flotation Concentrates.**—In discussing the problem of nodulizing blast-furnace flue dust, in the November *Bulletin* of the A. I. M. E., Mr. James H. Payne gives some data on similar treatment of copper concentrates produced by flotation. Tests on Braden oil-floated concentrates were so successful as to lead that company to adopt the process. Fuel consumption is not over 6 gal. per ton, and in many cases is less. The flue dust produced by the kiln is practically *nil*, although some of the material treated has been as fine as 82 per cent minus 100-mesh. The amount of sulphur in the nodules is under control. The upper limit for good working seems to be about 15 per cent, but between 5 per cent and 15 per cent good work can be done. This makes pyritic blast-furnace smelting of concentrates possible. The size of the nodules varies; with a high sulphur product the nodules run smaller than with low sulphur. Nodulizing of sulphide concentrates, and pyritic smelting, opens a new and interesting field. The process is so cheap as to make it appear possible to compete with roasting and reverberatory smelting.

In the same discussion, Mr. R. M. Draper adds that nodules from El Cobre concentrates are satisfactory from a blast-furnace point of view, when charged cold. The nodulizing kiln could easily handle 60 tons of concentrates a day, and he believes it possible to increase this to 75 tons. In a screen test of nodules from El Cobre concentrates he shows over 95 per cent between 3 in. and 16-mesh, 2.5 per cent between 16 and 30-mesh.

### Gold and Silver

**Ore Treatment at the Chaffer's Mill, Kalgoorlie.**—A mill system said to represent the last word in the treatment of the ore at the southwest of the Golden Mile, Kalgoorlie, Western Australia, is described in the Aug. 5 issue of the Australian *Mining and Engineering Review*, by J. D. Connor. The ore is a hard, tough silica and softer quartz dolerite, containing precious metal irregularly disseminated in the free state, as telluride and locked in pyrite. The treatment method comprises dry crushing in Krupp ball mills to 100-mesh, followed by roasting in Edwards furnaces. The roasted ore is mixed with cyanide solution and ground in pans to a slime fine enough to pass 200-mesh. Amalgamation will be introduced at this point to catch any coarse gold. The slime will be thickened and agitated and filtered in a Ridgway vacuum filter. Precipitation will be by zinc shavings. Dry crushing is recognized as a dirty process, and provision is made against excessive dust by means of fans drawing dust from the ball mills and discharging it into a settling chamber.

### Concentration

**The development of the round table at Great Falls, Mont.**, presents an interesting example of the survival of one of the oldest forms of concentrating devices. The paper on this subject read at the Salt Lake meeting of the A. I. M. E. by Mr. Arthur Crowfoot gives the history of the round table and its development from the stationary Cornish buddle. Many experimental data also are given, showing the reasons for adopting this type of machine in an important position in the flow-sheet of a modern copper concentrating mill. The paper contains extensive experimental data on wood, linoleum, cement and canvas surfaces, and conical and conoidal decks. The author is of the opinion that the round table will continue to maintain its supremacy over other types of machines for the concentration of minus 0.07-mm. slime from the ores of the Butte district as long as wet mechanical concentration is the most satisfactory method of recovering the valuable minerals from that class of material.

### Smelter Fume Recovery

**Electrical fume precipitation by the Cottrell process** has been adopted at the Garfield smelter for the treatment of gases from the converters. The principal object is the recovery of lead fume. As described by Mr. W. H. Howard in the August *Bulletin* of the A. I. M. E., the process was adopted after experimenting with bag-house recovery as well as with the electrical process. Bags lasted only a few hours, due to the presence of an excess of unneutralized acid in the gases. One of the important developments of the experimental work on electrical precipitation was the adoption of iron pipes with axial wire electrodes in place of the regulation plates and pubescent electrodes which were first used at Coram, Cal. Another important development was the discovery that fractional precipitation of the constituents of the gas could be accomplished by successive treatments at different temperatures, the solid matter being precipitated at higher temperatures in one set of tubes and the acid, water and additional solids at a lower temperature in another set.

In Fig. 2 is shown a cross-section of the precipitating plant for converter fume. The converter gases will first pass through a 1000-ft. steel flue of 210 sq. ft. cross-sectional area, in which the cuprous material will be collected and the gases cooled. The precipitator consists of seven units containing 360 5-in. pipes, 10 ft. long, per unit. The gas velocity through the pipes will range from 9.6 to 12 ft. per second, according to the number of units in operation and the volume of gas delivered. Gases from the converter flue will enter chambers below the pipes, pass through them to the upper chambers and thence to the flue leading to the stack.

The electrical apparatus comprises seven complete motor-generator-rectifier sets and transformers.

A set consists of a 30-hp., 250-volt, direct-current motor, direct connected to a 20-kw., 4-pole, 60-cycle, 220-volt single-phase alternating-current generator. The 220-volt current is stepped up to 20,000 to 30,000 volts by means of a 20-kw. transformer and then led back to the rectifier, which is on the same shaft with the motor generator. Here it is rectified before going to the treater. The voltage before going to the transformer may be regulated to any desired value by varying the field excitation with a rheostat located at the switchboard.

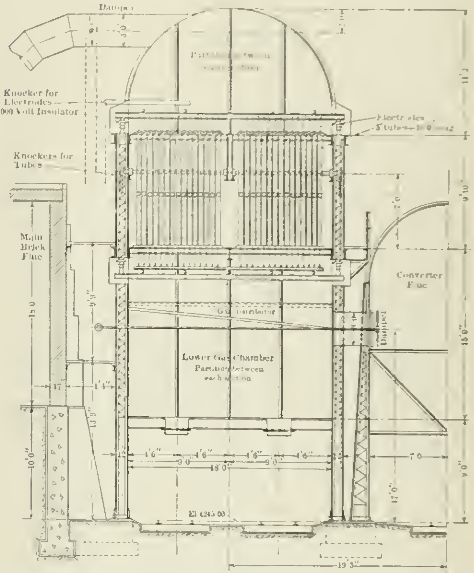


FIG. 2—CROSS-SECTION OF 360-TUBE UNIT FOR ELECTRICAL FUME PRECIPITATION

### Crushing and Grinding

**Laws of Kick and Rittinger.**—In his presidential address before the Chemical, Metallurgical and Mining Society of South Africa, published in the August *Journal* of the society, Prof. G. H. Stanley discusses the moot question as to the correctness of the laws of crushing promulgated by Kick and Rittinger. The author finds comparison of the two laws somewhat difficult "because the two laws do not deal with the same set of circumstances. Rittinger starts with a piece of ore of a certain size and compares the work done in breaking it into pieces of other sizes, while Kick, on the other hand, compares the work required to break, in a similar manner, pieces of ore of different sizes. In short, Rittinger refers to a constant total quantity, and Kick to a variable quantity." The author then proceeds from a mathematical discussion to deduce from Kick's law an expression of the same nature as Rittinger's, dealing with a constant total quantity. He finally arrives at this expression:

"The work required to reduce a given weight of rock from one size to another is proportional to the log of the $\frac{\text{initial}}{\text{final}}$ diameter." Analyzing his calculations, the author states: "Practically it shows that provided the degree of reduction is small, experimental results might almost be in accordance with the Rittinger theory, and this has undoubtedly given much support in the past. As the size of the particles diminishes, however, the increase of surface is much more rapid than the work required to produce it, and, as stated by Richards, this was experimentally found to be the case by Von Reytt; and though the latter's object was apparently to prove the correctness of Rittinger's law, his results, on the contrary, tend to confirm the deductions I have made from Kick's."

Based on the author's statement of the law, he makes comparison of the efficiencies of breakers, stamps and tube-mills. He does "not consider the data available are sufficient for the close comparison of our crushing practice with theory, and, hence, for an exact calculation of efficiency, since we have not available, for instance, the real average size of the final product, or indeed any of them, but by making some assumptions some interesting results are obtained."

He then assumes that the average size of feed to the different machines and the average size of their products are as follows: Breaker, 6 in. and 1½ in.; stamps, 1½ in. and 0.1 in.; tube-mills, 0.15 in. and 0.004 in. These figures give respective ratios of $\frac{\text{original}}{\text{final}}$ diameter of rock of 4.0, 15.0, and 37.5, the logs. being 0.602, 1.176, and 1.574, respectively.

"The efficiency of the three types is expressed as $\frac{\text{actual}}{\text{theoretical}}$ tons per horse-power. The theoretical can only be determined from the results of measurements of the work required to break known cubes, and this is not available; it may, however, be taken as a function of a constant *K*. In the three cases cited the theoretical tons per horse-power will obviously be inversely proportional to the theoretical work required, *i.e.*, as $\frac{1}{0.602} : \frac{1}{1.176} : \frac{1}{1.574}$ and is then a product of these figures, and *K*, *i.e.*, $\frac{K}{0.602}\ \frac{K}{1.176}\ \frac{K}{1.574}$, in other words, the breaker should crush more tons per horse-power than the stamps, and the stamps more than tube-mills; but unless the practical figures obtained are in the same ratio the efficiencies will not be equal. Assuming that the tons per horse-power per day in the three cases are 12, 4.5 and 2, the efficiency will be proportional to $12 \times 0.602$, $4.5 \times 1.176$, and $2 \times 1.574$ or 7.22:5.29:3.15, *i.e.*, efficiency is proportional to output per horse-power × log $\frac{\text{initial}}{\text{final}}$ diameter. Admittedly these figures can only be rough approximations for want of accurate data, and the subject is important enough to justify an extended investigation with the object of obtaining reliable figures. I think the average diameter is probably less than I have assumed, the error being probably greater in the finest size, which would tend to show the tube-mill, in the calculation, in a less favorable light than it deserves. Nevertheless, assuming they are not very far from the truth, it indicates that the tube-mill is considerably more efficient than it is considered to be in some quarters.

**Electric Precipitation of Fume.**—Supplementing the paper of Mr. W. H. Howard on electrical precipitation at Garfield, read at the Salt Lake meeting of the A. I. M. E., Mr. Edgar M. Dunn offers in the November *Bulletin* of the Institute some data on similar work at Anaconda. A feature of the work at Anaconda is the experimentation with large-diameter pipe treaters. Those at Garfield are but 5 in. in diameter, but at Anaconda 3-ft. and even 4-ft. pipe treaters have been tested. In the treatment of mixed roaster and converter gases 3-ft. pipes have been used, 20 ft. long, and good clearance has been obtained with a velocity of 5 ft. The single axial discharge electrode is No. 29 nichrome wire, and the current from 150,000 to 160,000 volts. Blast furnace gases did not give so good clearance, probably due to poverty in moisture and $SO_2$ as compared with roaster and converter gases. Tests will be made with 4-ft. treaters and voltage up to 220,000.

Fractional precipitation of gas constituents at successively lower temperatures has been used successfully in arsenic refining. Formerly it was the custom to volatilize arsenic from flue dust in two stages, the second being a refining stage to get rid of dust driven over in the first volatilization. It has been found that fractional precipitation, first at 310° C. and then at 90° C., gives two products, the first consisting mainly of the dust and the second of white arsenic 99.7 per cent pure. This will eliminate the necessity of two furnace treatments as heretofore.

**Tube-Mill End Liners.**—The following description of a combination wood and steel end liner for tube-mills is given in the August *Journal* of the Chem. Met. & Min. Soc. of S. Africa, by Mr. J. F. Pyles. The author states that the idea of using wood and steel for tube-mill liners is not original, but believes that its practical utility has not been proved previously with regard to end liners. The adoption of this liner arose from the necessity of installing one that would not fall out, and from the importance of economizing steel.

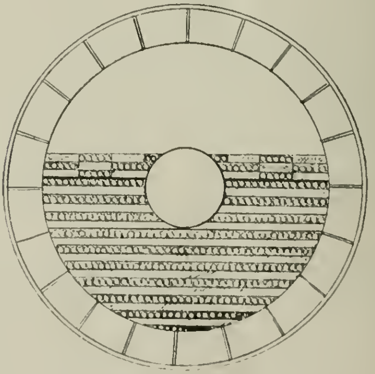


FIG. 1—TUBE MILL END LINER

As illustrated in Fig. 1, the liner is built around a sleeve 1½ in. thick. The annular outer portion is built of 6-in. chert blocks, and the intervening space of alternate courses of scrap steel cut in 6-in. lengths, pine boards 1 in. thick and 6 in. wide, and 6-in. pegs.

"The procedure in building the liner is as follows: First place the casting or sleeve in position, then build in the outer layer of chert blocks, which have been previously shaped to fit the mill. These blocks are placed in the mill with Portland or magnesite cement and keyed in position. A layer of 6-in. pegs is then put in with their axes parallel to the sleeve and their sides touching each other, and embedded in mortar. Next a board 1 in. thick and 6 in. wide, touching the chert circle at each end, is laid on the pegs and tapped into place. Mortar is placed on this board and the next row of pegs embedded in it, and so on until the liner is completed. The work of building this end liner will occupy one mason for half a day.

"The end has the following points to recommend it. It is inexpensive, both as to material and labor, and is quickly and easily installed. Owing to the wood absorbing the moisture from the cement, the end dries in a much shorter time than if only steel or chert were used. The swelling of the wood wedges the whole so tightly that all danger of the end, or any part of it, coming out is obviated.

"The life of the outlet end will be materially increased by staggering the wood and iron. This may be done by cutting the 1-in. board into pieces 6 in. square. Each row is then made by alternating 6 in. of steel with a 6-in. piece, and arranging the rows so that each piece rests on and is covered by steel. The pieces are placed with the grain of the wood parallel to the pegs."

### Chemical Engineering

**Cyanide from Coal Gas.**—Supplementing an article in our December issue, page 696, on Coal Gas Residuals, by F. H. Wagner, we present an excerpt from a paper on The Recovery of Gas Works By-Products, by C. C. Tutwiler, published in the October *Journal* of the Franklin Institute. The portion selected has special reference to the making of cyanide from coal gas.

"Cyanogen occurs in coal gas as free cyanogen $(CN)_2$, and hydrocyanic acid (HCN), both of which are gases. It is formed by the combination of a small percentage of nitrogen contained in the coal, with the necessary amount of carbon. The amount occurring in the gas is dependent upon the temperature of distillation, high heats being conducive to a high cyanogen yield. A temperature of about 1735 deg. F. is said to be most favorable. The yield of hydrocyanic acid will then be between two and three ounces per thousand feet of gas. It is rare in this country that as much as three ounces are produced owing to the comparatively low heat carried. Several heats made in an American gas works showed something over two ounces; being higher at one station than at another in the same works, due presumably, to slightly different heats carried. At works where no attempt is made to remove the cyanogen from the gas, about 10 to 15 per cent is taken out in the ammonia scrubbers, and the rest more or less completely removed in the purifiers, occurring there as Prussian blue. Up to a few years ago the spent purifying material was the chief source of cyanides, but it was soon recognized that only a portion of the whole could be recovered in this way and attention was given to its recovery from the gas itself.

"Numerous processes have been devised for wet scrubbing, the earliest being the Knublauch system, which consists in bringing the gas, by means of a mechanical scrubber, into intimate contact with a solution containing an alkali and the salt of a heavy metal, preferably iron. In this way soluble ferro cyanides are formed and recovered from the wash liquor by evaporation and crystallization. There were several defects in the Knublauch system and at present it has given way to other systems which are more efficient and more easily controlled. All of these, however, except perhaps the process exploited by the British Cyanide Company are based upon the Knublauch principle. A brief outline of the most important systems in use to-day is as follows:

"*Feld Process.*—In the Feld system, the cyanide washer is placed immediately after the ammonia scrubber, operating on gas freed from ammonia. The washer employed is usually of the standard rotary or bubbling type. Solutions of lime and ferrous sulphate are used as the scrubbing material, being introduced separately and continuously into the washer. The product obtained is a solution of calcium ferrocyanide, from which the pure salt can be crystallized.

"*Stavorinus Process.*—In the Stavorinus process the washer is placed immediately after the tar extractor and operates therefore on gas containing ammonia. The scrubbing material employed is a solution of potassium carbonate, and iron carbonate made from ferrous sulphate in suspension. The product obtained is a soluble alkaline ferro cyanide. Although the system is arranged for a continuous flow, the process is really intermittent. Two or three times a day a quantity of saturated liquor is drawn from the last bay of the scrubber and fresh liquor poured in. Since a large amount of ammonia is dissolved with the soluble cyanide, it must be recovered by boiling off in some form of concentrator. The residual sludge is then pumped into a filter, where it is converted into a clear solution and a cake, the solution consisting of potassium ferrocyanide, potassium sulphide and potash. This liquor is evaporated until it throws down the salt.

"*British Cyanide Process.*—In this process the gas is treated, immediately after the tar extractor, as in the Stavorinus process. A mechanical scrubber is employed having nine bays. Over eight of these bays is fixed a conical cup for holding the sulphur. Ammoniacal liquor is pumped into the washer at the outlet end, and granular sulphur is introduced intermittently into the eight bays. Ammonium sulphocyanide is formed and is disposed of as such.

"*Bueb Process.*—In the Bueb process, the cyanide washer is placed after the tar extractor. This process also operates on gas containing ammonia. A ferrous sulphate solution is employed as the scrubbing material. The product produced is a mixture of insoluble cyanides, which is sold in its crude state."

## Notes on Chemistry and Metallurgy in Great Britain

(*From Our Special Correspondent*)

### The Metallography of German Silver

In a paper communicated to the Chemical Society Mr. Frank Charles Thompson described a research of considerable interest carried out for the most part on actual commercial specimens of german silver subjected to ordinary works treatment and yielding results typical of the industrial alloys. The author remarked that almost the whole of the more directly industrially important knowledge of the copper-zinc-nickel alloys was contained in a paper by Hudson (J. Inst. Metals, 1913; i; 101), who, starting with the cast-steel metal traced its structural alterations on rolling and annealing; but only examined metal of one composition. Since these alloys consist entirely of Tafel's *alpha* solution (*Metallurgie*, 1908; Vol. V., page 419) they are metallographically strictly comparable with the *alpha* brasses. Further valuable information in M. Charpy's classical paper "Contributions a l'etude des Alliages" (Paris, 1901). Our present knowledge of the micrography of the german silver alloys might be briefly summarized as follows: The commercial alloys consist entirely of the *alpha* solid solution, since the appearance of the *beta* phase is accompanied by a brittleness that renders them incapable of receiving the work to which they must be subjected. In the cast state the structure consists of cored crystals, which in these nickeliferrous alloys are remarkably persistent under both mechanical and thermal treatment. Annealing at a proper temperature will in time remove this coring, giving place to a structure consisting of entirely allotrimorphic crystals in which, however, unless the annealing has been very prolonged, traces of the cast structure may still be recognized. Like all *alpha* solutions these alloys are rolled cold, which treatment produces, if carried far, an indefinite linearity in the direction of greatest extension. The cord structure often persists after repeated rolling and annealing. When the cold-worked metal is annealed above a certain (minimum) temperature a recrystallization is effected, the degree of coarseness of which is increased as the annealing temperature is raised and as the time is prolonged.

In dealing with the effects of deoxidants the author stated that in the photomicrographs of the aluminium alloy an incomplete network, faintly to be seen, might afford an explanation of the idea held by certain makers of german silver that the presence of even small amounts of aluminium is detrimental to the properties of the metal. He, however, found that the refining action of 0.25 per cent of manganese or 0.5 per cent of aluminium was remarkable, and was the more curious because, at any rate in the case of manganese, the whole amount added had passed into the slag, hardly a trace remaining in the alloy. The finer structure of the deoxodized alloys imparted to them a tensile strength higher than that of the untreated metal; and in view of the fact that no chemical difference existed between the treated and the untreated specimens, no explanation appeared to meet the case so well as that of the amorphous cement theory of the intercrystalline boundaries.

The author also drew attention to the following analogies between german silver and steel. In practice the annealing temperature-range from 900 deg. to 700 deg. is the same for each; and the temperature falls as the percentage of nickel increases in the non-ferrous alloys and as the carbon increases in the steel. In each case overheating will cause a reintroduction of the cast structure with an accompanying loss of ductility. The mechanical properties of german silver are not dissimilar from those of a normal mild steel. In each case, increased nickel content means a diminution in the size of the grain. The mechanism of the recrystallization after cold work appears to follow the same course for both metals. As shown by the austenitic steels the original cast structure of each is the same; and there is reason to believe that the peculiar persistence of the cored structure in german silver has a counterpart in the ferrous metals. The author's conclusions are: That the oxygen in german silver is probably present as finely disseminated oxide of zinc; that deoxidants have a marked influence in giving a finer crystalline structure accompanied by better mechanical properties; that a curious reproduction of the "as cast" structure has been found in burnt metal; that lead and tin both cause separation of distinct components, probably lead and a compound of copper and tin respectively; and, finally, that marked analogies exist between the metallography of german silver and steel, and between their mechanical and annealing properties.

### A New Gyroscopic Compass

Mr. E. Kilburn Scott and Capt. V. H. Rozie have devised a new form of gyroscopic compass which they have named the "Sea Star Type," and which was described and compared with the Anschutz and the Sperry instruments in a paper read before the Institute of Marine Engineers by Mr. Kilburn Scott. The author remarked that the Anschutz type of compass was of pendular construction and thus free to swing by the action of gravity. The Sperry gyroscope had a wire suspension, and was fitted with automatic "follow up" mechanism to prevent twisting of the wire by the movement of the wheel and to overcome friction about the vertical axis instead of this being performed by the gyro-wheel. The motor of the "following" mechanism also drove the compass card and transmitting gear, and so left but little work to be done by the wheel. It was an essential feature. The source of errors affecting instruments of these types is traceable to their being pendular and dependent on the force of gravity for their effectiveness.

The compass designed by Captain Rozie and himself did not depend on gravity for the magnitude of its righting momentum which was determined by the deflecting momentum to be counteracted; and this was effected automatically and forcibly. The gyro-wheel is not liable to ballistic disturbance in consequence of its being mounted with the horizontal axis non-pendular. They had in view the elimination of correction tables and mechanical correction, and also the production of a small, cheap compass which could be used on merchant ships and aircraft. The increased sensitiveness requisite in a small instrument had been attained by rotating the gyro-wheel in a direction opposite to that of the earth's axial rotation, so that the direction of rotation of the wheel was dextroroal when regarded from the northern side, with the consequence that the wheel was permanently in a state of unstable equilibrium. Then as soon as the slightest deflection occurred the tendency to increase deflection became very strong and caused the instant starting of the motor to remedy the deviation. Consequently the sensitiveness in meridian was very great, and the kinetic energy of the gyro-wheel became of less importance than it was in other instruments. In the Anschutz and the Sperry compasses the direction of rotation of the wheel coincides with that of the earth's rotation.

### The Tensile Properties of Copper at High Temperatures

Dr. G. D. Bengough and Mr. D. Hanson gave the results of their investigations of the effects of high temperatures on copper in various atmospheres. They found that the nature of the atmosphere was an important factor; and that an oxidizing atmosphere at high temperatures gave a high degree of ductility. In a neutral atmosphere, at all temperatures from 20 deg. C. up to 1000 deg. C. pure unannealed rolled copper retains all its superior strength as compared with annealed copper. With pure annealed copper fracture occurs through the crystals at all temperatures below about 700 deg. C., while at all higher temperatures above 750 deg. C. it occurs between the crystals; and between 700 deg. and 750 deg. it may occur in either way but has a preference for the intercrystalline path. Confirmation was obtained of the existence of a range of low ductility at temperatures about 250 deg. to 450 deg. C.

Small quantities of oxygen or of arsenic in copper have the effect of decreasing the tensile strength at high temperatures, but increased ductility has also been observed. In an atmosphere of hydrogen, at temperatures above about 720 deg. C., the test bars gave a tensile strength about half a ton per square inch lower than those tested in a neutral or an oxidizing atmosphere. The authors considered that this is probably due to reduction of copper oxide, which action might weaken the bars and ultimately cause cracking. As a whole, the results of the tensile tests are consistent with the theory of the crystals of copper being enveloped in a cement which at low temperatures is stronger than the crystals themselves but weaker at high temperatures; yet there are two points of interest which must at present be excepted from this explanation.

### Heating Alloys in Vacuo

A paper by Mr. W. E. Thorneycroft and Professor T. Turner gave some very interesting results of experiments carried out with the object of determining the effect of percentage of copper on the rate of the removal of zinc from copper-zinc alloys when suitably heated in a vacuum.

The authors arrived at the following conclusions:

Alloys containing upwards of 40 per cent. of copper can be separated quantitatively into their constitutent metals, but when the copper content is less than 40 per cent. some of the copper is volatilized with the zinc. Copper-zinc alloys which contain a high percentage of zinc are slightly more volatile than pure zinc, and it is probable that one particular alloy will be found to have the lowest temperature of volatilization out of the whole series of alloys. Alloys containing a high percentage of copper require for complete separation of the zinc a degree of heat decidedly greater than that requisite for the volatilization of the separated zinc.

### Electrolytic Iron

Among the papers presented for reading at the abandoned Paris meeting of the Iron and Steel Institute was one by Prof. L. Guillet dealing with the commercial production of electrolytic iron. The author stated that the Le Fer Company, of Grenoble, has taken out patents since 1910 for the electrolytic manufacture of iron. The method consists essentially in the use of a revolving cathode in a neutral solution of iron salts, the neutrality of which is maintained by constant circulation about the anode. Periodic additions of oxide of iron effect depolarization by partially removing hydrogen from the surface of the cathode, and permit the use of a current having a density as high as 1,000 amp. per square meter. From a solution made with ordinary pig iron a product can be obtained of a very high degree of purity. After removing occluded gases by annealing the metal contains an average of only 0.004 per cent. of carbon, 0.007 per cent. of silicon, 0.006 per cent. of sulphur and 0.008 per cent. of phosphorus. When taken from the bath the metal is hard, very brittle and contains occluded gases, notably hydrogen. Sir Robert Hadfield obtained 28.8 cc. of gases from a sample of the iron weighing 34 grammes, having a volume of 4.33 cc., by heating it in a vacuum for four hours at 800 deg. C. to 1,100 deg. C. and for two hours more at nearly 1,400 deg. C. The relative volumes of the gases were, hydrogen 18.8, carbon monoxide 7.4, carbon dioxide 0.2 and oxygen 2.2. The Brinell hardness of the crude iron is 193 with a ball of 10 mm. in diameter and a load of 3,000 kg., and the micrographic structure is composed of exceedingly numerous fine needles, closely resembling martensite. Annealing in magnesia for two hours at 900 deg. C. reduces the Brinell hardness to 90 and imparts a perfectly normal micrographic structure.

Tensile tests on tubes gave a breaking strength of 30.9 to 32.8 kg. per square millimeter (about 20 tons per square inch), with an elongation of 40.2 to 42.1 per cent. in the direction of the axes. Annealed tubes withstand compression tests producing more than ordinary deformation without exhibiting any sign of fracture. One tube 100 mm. in diameter and 0.75 mm. thick when subjected to a pressure of 1,200 lb. per square inch showed a deformation as regular as if it had been squeezed in a press. Another portion of the same tube was exposed for 2½ months to a temperature of 120 deg. in a steam boiler and then withstood a pressure of 1,200 lb. per square inch without any sign of fracture being perceptible.

Tubes are being manufactured by Messrs. Bouchayer and Viallet, whose plant is equal to an output of 100 lengths per day. The tubes are uniformly 4 metres long, and vary in diameter from 100 mm. to 200 mm. and in thickness from 1 mm. to 6 mm., and the great regularity in the thickness obtained contrasts strongly with the inequalities prevailing in the tubes made in the ordinary way, particularly when the thickness is less than 6 mm. The manufacture of sheets is still in the experimental stage, but hopes are entertained of their direct production without rolling. The quality of the iron is first rate, and as it can be worked with remarkable facility, it is especially suitable for stamping both as black annealed plate and as tinplate. The great purity of the sheets endows them with a particular value in the construction of electrical machinery by reason of the increased efficiency to be secured and the reduction in the weight of the material to be effected.

For the manufacture of steel the electrolytic iron appears likely to compete quite successfully with the best Swedish iron. Its quality is very regular, and its brittleness enables it to be broken into small pieces of any required size, and consequently it lends itself to a more uniform cementation than does ordinary material. Tool steel and special steel giving results at least equal to those obtained with similar steels made from Swedish iron have already been produced at several steel works. Working with a current density of 1,000 amp. per square meter a yield of two tons of very pure iron per kilowatt-year is obtained; but when the density is reduced to 500 amp. per square meter the output per kilowatt-year is nearly doubled, and on the latter basis the total cost of production, making ample allowance for waste of pig iron, depreciation, etc., is estimated at from £6 to £7 12s. per ton, according to local conditions.

### Electrolytic Iron

It appears that the process for the production of electrolytic iron in tubes and sheets described in the paper by Prof. L. Guillet had, according to a statement in the *Times*, already been worked out in England by Mr. S. Cowper-Coles, and that works are to be erected in the Midlands for the commercial manufacture of sheets, tubes, etc. In 1908 Mr. Cowper-Coles read a paper before the Iron and Steel Institute in which he gave details of the electrolytic production of finished iron tubes and sheets in one operation. In his process he employed a mandrel revolving at a critical speed in order to give sufficient "skin friction" between the electrolyte and the deposited metal to obtain a close homogeneous deposit and to permit the use of a high-current density, whilst the solution was kept neutral by circulation over the anode. In the following year a license was granted to Mr. Boucher to work the process in France and Switzerland, and a small trial plant was put down in Switzerland with which a number of tubes was produced. The Compagnie Le Fer was subsequently formed to acquire this license. (The Cowper-Coles process was described in detail in a paper by Messrs. W. Palmaer and J. A. Brinell in our issue of April, 1913, Vol. 11, page 197.)

### The Influence of Coke on Corrosion

The paper by Mr. Arnold Philip, an abstract of which was given in last month's letter (page 724), which expressed views and quoted results quite opposite to those given by Dr. Bengough and Mr. Jones in their report to the corrosion committee of the Institute of Metals has called forth an energetic reply from those gentlemen. They expressed surprise that the results of Mr. Philip's researches should have been so completely contrary to those obtained in their own investigations, and decline to admit that the contact of coke with condenser tubes in seawater induces electrochemical action. They point out that Mr. Philip carried out his experiments under conditions essentially different from their own tests; and that, consequently they propose to undertake further investigations, as at present there is uncertainty as to how the variation of conditions affects the results. In reply to Mr. Philip's definite assertion that in all his experiments, without exception, he found that the presence of coke caused accelerated corrosion, and also apparently dezincification in two days in seawater at ordinary temperatures with accelerated action at higher temperatures. They state that in no case did they observe dezincification in less than seven days at 50 deg. C., or about seven months at ordinary temperatures, whether coke were present or not.

### Water Softening

The results of a series of experiments are recorded by Mr. W. Buscoe Baron in the Manchester paper *Vulcan*. In summarizing the results he considers the importance of bringing water to which softening chemicals are added, intimately in contact with crystalline calcium carbonate to be the means by which the lowest results are obtained. He points out that every effort should be made to soften the water without involving excess of alkali. The experiments dealt with lime permanent hardness.

### Market Prices

*October*, 1914.

| | | £ s d |
|---|---|---|
| Aluminum ingots, ton lots | | 88. 0. 0 |
| Alum, lump, loose per ton | £5.5.0 to | 5.10. 0 |
| Antimony, black sulphide powder, ton | | 23. 0. 0 |
| Borax, British crystal, cwt | 18/6 to | 19. 6 |
| Copper sulphate, ton | | 22. 0. 0 |
| Caustic soda, 70 per cent, per ton | 9/9 to | 10. 3 |
| Copper ore, 10 to 25 per cent, unit | | not fixed |
| Ebonite rod, lb | | 3. 0 |
| Hydrochloric acid, cwt | | nominal |
| India rubber, Para, fine, lb | | 2. 7½ |
| Mica, in original cases, medium | 3/— to | 5. 0 |
| Petroleum, Russian spot, gal | | not fixed |
| Quicksilver, Spanish, bottle | | 10. 5. 0 |
| Sal-ammoniac, cwt | | not fixed |
| Sulphate of ammonia, ton | | 10.10. 0 |
| Shellac, per cwt | | 3. 0. 0 |

The Metal Exchange remains closed; prices are therefore approximate.

*Copper*—Best selected copper was fixed at £56.5 to £56.15. on the 6th, £55.10. to £56 on the 9th, and closed at £54.5. to £55. Copper has been obtainable at £52.10.

*Tin* opened at £134 to £136, and was harder in the third week. From the 16th to the end of the month it was £133.

*Haematite* opened at 66/-. On the 16th was 66/- at Glasgow, and the same on the 23rd, but had fallen to 62/- by the 30th.

*Scotch Pig*—Closes at 55/4½d.

*Cleveland*—Opened at 50/11; selling at 50/0½ on the 9th, subsequently went lower. Rose a little on the 19th to 49/6½, afterwards becoming quieter and closing at 49/-.

*Lead*—Opened at £19.15. and closed at £18.10.

**American Peat Society.**—The 1915 meeting of the American Peat Society will be held in Detroit, Mich. Mr. Carl Kleinstück, of Kalamazoo, Mich., is the president, and Mr. Julius Bordollo, Kingsbridge, N. Y., the secretary of the American Peat Society.

**Thermit in a Municipal Repair Plant.**—The repair shop connected with the Bureau of Water, Department of Public Works, Philadelphia, Pa., has adopted thermit for heavy repairs. Some repairs carried out in this shop are the subject of an interesting illustrated article in issue 3, 1914, of *Reactions*, published by the Goldschmidt Thermit Company, of New York.

## Recent Chemical and Metallurgical Patents

### Iron and Steel

**Briqueting Iron Ores.**—The use of tar, from which water and the light and middle oils have been removed, is suggested as a suitable binder for iron ores, in a patent granted to Mr. Georg Crusius, of Gross-Ilsede, Germany. The inventor claims that the use of ordinary soft tar is not advantageous on account of its content of light oils that distill out of the briquets when subjected to the heat of the furnace; but the use of specially prepared tar is without these objections and gives good results. (1,116,024, Nov. 3, 1914.)

**Cooling Open-Hearth Furnace-Ports.**—A mechanism for cooling the arches and maintaining the gas ports of metallurgical furnaces, patented by Mr. Frank E. Parks, of Pueblo, Colo., consists in a port structure comprising a water-cooled frame of separate hollow cooling elements. Each cooling element is provided with several conduits for supplying a cooling fluid, and provision is made for maintaining a circulation through one or more conduits while others may be inactive. (1,113,245, Oct. 13, 1914.)

### Copper, Lead and Zinc

**Extracting Copper from Carbonate and Oxide Ores**—In several patents recently granted to Henry R. Ellis, of Salt Lake City, Utah, he amplifies a process of extracting copper from carbonate and oxide ores by solution with carbonate or bicarbonate of sodium or potassium, and electrolysis of the solution. The present invention specifically makes use of a mercury cathode and insoluble anode. It is claimed that when using a mercury cathode a current density may be used of many times that permissible when copper is the cathode. The ore is crushed in solution to a thin slime and conveyed to the electrolytic vat where the copper is precipitated. The slime is kept in suspension by agitation. One method of using the mercury cathode is shown in Fig. 1, in which the vat $T^3$ contains a revolving shaft $S^2$ carrying wheels $a^3$ with an iron anode cylinder $A^3$ of perforated sheet metal or woven wire. Around this cylindrical anode is arranged the concentric cathode of amalgamated copper, connected with the cylinder $A^3$ by non-conducting radial supports *r*. The cathode revolves in a bath of mercury $m^3$. (1,115,521-2-3, Nov. 3, 1914.

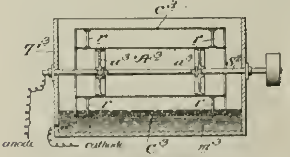


FIG. 1—ELECTROLYSIS OF ALKALINE COPPER SOLUTION

**Heating Leaching Solutions.**—A method of heating copper leaching solutions by the heat absorbed from water used in ore-coolers, is patented by Frederick Laist, of Anaconda, Mont. The idea is illustrated as applicable to a form of ore-cooler patented by Mr. Laist and reviewed in this journal, May, 1914, page 352. In that cooler the hot ore is cooled by means of water pipes extending the length of a drum, entering at the point of ore discharge. The hot water issuing from these pipes at the end of the drum at which hot ore is charged, is then led to a tubular heater where its heat is transferred to a leaching solution. The latter flows through the tubes of the heater, which are surrounded by the hot water from the cooler. (1,115,689, Nov. 3, 1914.)

**Furnace for Producing Lead Pigments.**—In the manufacture of lead pigments, for example minium, or red lead, accurate control of conditions in all parts of the furnace is an essential. To secure this control of Mr. Clifford D. Holley, of Detroit, Mich., has designed and patented a reverberatory furnace with a pair of grates at opposite ends of the hearth, and a number of waste-gas exits at different points above the hearth, so that the course of the flame and fire gases over the hearth can be changed at will. The firing may be by any of the usual means—coal, coke, gas or oil. The furnace has charging and discharging doors at back and front, respectively. (1,116,703, Nov. 10, 1914.)

**Retort Discharging Machine.**—In Fig. 2 is shown a side elevation of a machine patented by John J. Simmonds, of Iola, Kans., adapted to the operation of discharging zinc retorts after the distillation process is complete. It comprises a number of mechanically driven elements arranged to enter the retorts of a furnace and clean them out. The elements consist of endless chains moving over sprocket wheels and carrying scrapers which progressively remove the residue from the retorts simultaneously with the advance of the elements. The machine is mounted on a car movable along a track in front of the furnaces. (1,110,081, Sept. 8, 1914.)

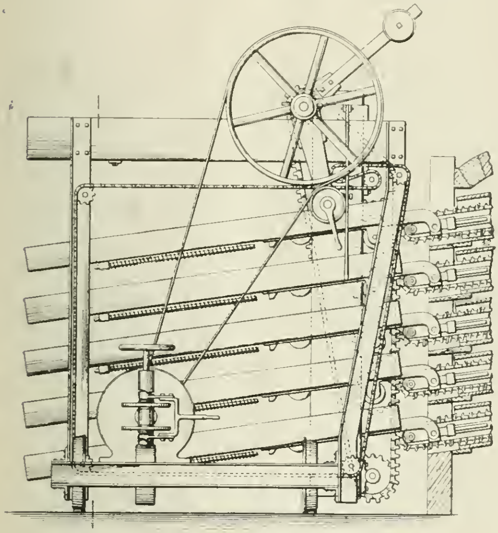


FIG. 2—RETORT DISCHARGING MACHINE

**Recovery of Zinc from Refuse.**—The prevention of metal loss in the zinc-bearing refuse of brass foundries and rolling mills is the purpose of a process patented by Mr. Ralph R. Parish, of Waterbury, Conn. The material is gradually introduced into a tank containing a 1 per cent to 5 per cent solution of sulphuric acid. The mixture is continuously agitated with compressed air, and when the density of the zinc solution has reached from 30° to 45 Baume the remaining acid is neutralized by the addition of an excess of zinc-oxide refuse. This precipitates iron, and agitation is continued until all iron has been removed from solution. If manganese is present ozonated compressed air is used to convert that metal into an insoluble oxide. Freed from iron and manganese, the zinc solution is either decanted or filtered. It still contains such impurities as cadmium and copper, but these are removed by precipitation with zinc in the form of dust or shavings. The resulting pure solution of zinc sulphate is then evaporated to crystallization or electrolyzed to produce pure zinc metal. (1,104,922, July 28, 1914.)

**Apparatus for Isherwood Zinc Process.**—In Fig. 3 is shown an extracting and filtering apparatus patented by Mr. Percy C. C. Isherwood, of Bushey Heath, England, for the treatment of refractory zinc ores. It consists of a longitudinal casing mounted on rollers and adapted to be revolved. A central partition extends the length of the casing, dividing it into two separate parts, each with manholes as shown. On each side of the central partition is a filter with suitable outlets for discharging filtered solution. The charge of ore and solvent is introduced into one compartment of the casing, and steam is forced in under pressure, thereby heating the solution to a high temperature. The casing is then revolved until this compartment is lowermost, and may be reciprocally moved in that position to aid in solution of the metal. In the meantime the upper compartment is being charged. When the treatment of the first charge is complete the casing is rotated 180 degrees, whereupon the coarse particles in the first charge fall on the filter and underly the finer particles. Filtration of the solution can then proceed under the internal pressure generated by the steam. After filtration the casing is again rotated and the tailing discharged through the manholes. Both compartments are alternately in use in different stages of a complete cycle of treatment, effecting economy in time and space. The process has been tried in an experimental plant at Perth Amboy, N. J., and it is stated that experiments with it are to be continued on a larger scale at Keokuk. (1,110,790, Sept. 15. 1914.)

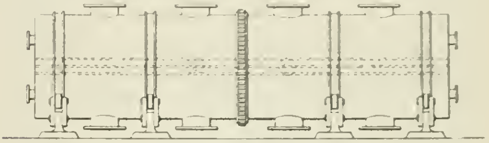


FIG. 3—ISHERWOOD ZINC DIGESTER AND FILTER

**Electric Zinc Furnace with Integral Condenser.**—A resistance furnace for the reduction of zinc oxide obtained as a product of igneous concentration is shown in section in Fig. 4, being the invention of Mr. Charles V. Thierry, of Paris, France. The heat is derived from the passage of a current through a resistor H of broken carbon resting on the hearth of the furnace between carbon terminals D, D′. The charge J rests on the resistor. The walls of the furnace adjacent to the longitudinal sides of the resistor, and the sole or hearth of the reaction chamber, either or both, form the condenser. Slots or crevices 6 in the walls and hearth provide for the evacuation of the gases and

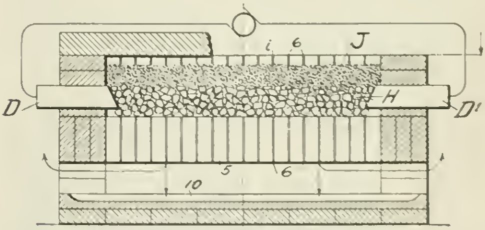


FIG. 4—ELECTRIC ZINC FURNACE WITH INTEGRAL CONDENSER

metal fumes, the latter being condensed and collected in an underlying receptacle 10.

In the beginning of an operation the gases evolved escape through the numerous fissures and, being under some pressure, will prevent the entrance of air. They will also assist in progressively heating the sidewalls of the fissures. The inner faces of the walls will become heated to the temperature of the resistor, and will be heated by conduction in a progressively diminishing ratio toward their outer surfaces. The inventor is of the opinion that these conditions are favorable to the condensation of zinc. ( (1,110,359, Sept. 15, 1914.)

**Sintering Zinc Retort-Residues.**—The preparation of zinc retort-residues for the recovery of their precious metal contents by smelting in the blast furnace is accomplished by burning them in heaps or piles, utilizing their contained coal as fuel. As outlined in the patent on the process granted to Mr. ARCHIBALD JONES, of Bartlesville, Okla., the beneficial effect of this treatment is three-fold: the carbon is eliminated, thereby reducing the weight and consequent cost of freight; the zinc content is greatly reduced, the sublimed zinc being condensed in the outer layer of the pile and subsequently recovered for retort reduction, and the material is sintered into a mass which, on being broken to suitable size, makes a good blast-furnace feed.

The residues are taken from the retorts and deposited on the ground over a system of trenches or flues made of fire-clay tile. One end of the main flue is connected with a source of air-blast of about 1 ounce pressure per foot of residue in the pile. Fuel may be used at points in the flue system in order to initiate the ignition, but ordinarily the 30 to 40 per cent of fuel in the residue is sufficient for combustion. As combustion is propagated throughout the mass, zinc is volatilized and condensed in a surface crust, which is removed and resmelted. The finished sinter is practically free from carbon and zinc, and can be smelted for recovery of other metals. (1,112,-010, Sept. 29, 1914.)

**Manufacture of Zinc Oxide.**—In a patent granted to Mr. J. A. SINGMASTER and assigned to the New Jersey Zinc Co., the inventor discloses a scheme for producing zinc oxide in a continuous operation. The process is claimed as an improvement on the Wetherill process using stationary grates. According to the invention the charge of ore and fuel is placed on a moving car, forming a traveling grate which advances through the combustion zone where the reactions take place with uniform combustion and complete utilization of all the valuable elements of the charge. Fig. 5 gives an idea of the furnace with its several flues for handling the gases evolved at different stages of the process.

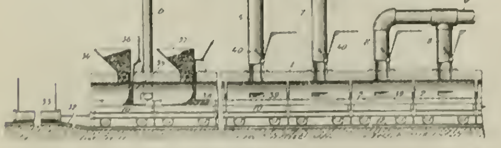


FIG. 5—CONTINUOUS PROCESS FOR MAKING ZINC OXIDE

The tunnel is of masonry, about 150 ft. long and 7 ft. by 6 ft. internal cross-section. The interior is provided with a series of partitions 2, depending from the roof and serving as baffles to prevent movement of gas between the combustion zone and the ends of the tunnel. From the pockets formed between these partitions leads an off-take for the gas or fume. These permit the separate disposal of the metallic and non-metallic fumes that come from a charge at different points in the tunnel. The first, as at 5, is for the non-metallic gases which may be used for fuel, being distillation products from the coal. The next, 7, is for the first metallic fume which may be of poor grade and not suitable to be mixed with the finest product of the furnace. The others, as at 8, are for the zinc oxide that is produced when the process is at its height, and are combined in a long flue 9, leading to the bags. Details of mechanical construction are given in the patent specifications. (1,112,853-54, Oct. 6, 1914.)

## Tin

**Detinning Process.**—The removal of tin from tin-coated metal may be accomplished by treatment with a slime containing a solution of a tin salt and gray tin, according to claims in a patent granted to WALLACE SAVAGE, of Piedmont, Ala. He claims to have discovered that a coating of ordinary white tin may be changed to a dark, amorphous, nonadherent powder known as gray tin by the catalytic action of gray tin, and that the change takes place most satisfactorily when gray tin is employed in connection with a solution of a tin salt, preferably tin ammonium chloride, known as "pink salt." The reaction occurs at ordinary temperatures, but is preferably brought about below a temperature of 68 deg. F. The slime is produced by dissolving 10 lb. of tin ammonium chloride in 100 gal. of water and mixing with this solution about 2500 lb. of gray tin. On application of this mixture to tin-coated metal, the tin is separated as an amorphous powder. (1,113,491, Oct. 13, 1914.)

**An improvement in detinning** by means of chlorine, using a mixture of air and chlorine, is patented by GUSTAV VON DER LINDE, of St. Tönis, near Crefeld, Germany. It consists in producing a uniform mixture of air and chlorine of suitable concentration by means of diffusion, and then allowing this mixture to act on the metal to be treated. The method of securing the uniform mixture is to pass chlorine into a chamber charged with distributing bodies filled with air, as for example Guttman's hollow balls. After the chlorine fills the chamber containing these bodies, air rapidly diffuses into the chlorine and forms a uniform mixture which is then distributed over the metal to be treated. By reduction of the pressure caused by the formation of tin chloride, air is again drawn through a seal into the distributing bodies so that the process of uniform dilution can be repeated. The process is performed in apparatus shown in Fig. 6, in which *a* is a receptacle charged with tin scrap, and which communicates with a chamber *d* through holes in the receptacle *a*. The chamber *d* is connected with chlorine supply pipes *b*

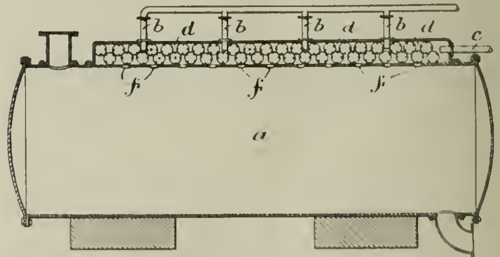


FIG. 6—APPARATUS FOR DETINNING

and a pipe *c* that leads to an acid seal. The chamber *d* is charged with hollow distributing bodies *f*. Chlorine is intermittently supplied to the chamber *d*, mixed with the air of the distributing bodies and finally admitted to the chamber *a*. When the pressure in the latter is reduced by the reaction, air is drawn into the chamber *d* through the pipe *c*, so that the distributing bodies again become filled with air. (1,116,176, Nov. 3, 1914.)

### Rare Earths

**Electrolytic Separation of Rare Earths.**—In describing a method for fractionally electrolyzing solutions containing yttrium, erbium, thorium, cerium and zirconium, Louis M. Dennis, of Ithaca, N. Y., states that heretofore experiments on such separation have failed due to the fact that the compounds formed by electrolysis have adhered to the electrode in such manner as to increase the internal resistance of the cell to a point where appreciable separation was impossible. He has discovered that if the surface of the cathode be kept free from adhering deposits, the elements referred to may be fractionally separated in the form of compounds, such as hydroxides. In the preferred form of apparatus he uses a glass cell with a mercury cathode and platinum anode. The following example of electrolysis is cited: 25 grams of the oxides of the yttrium group of rare earths may be dissolved in nitric acid and evaporated to dryness. The residue is taken up with 500 cc. of water and electrolyzed for 6 hours at 9 volts. At the end of that time a precipitate of hydroixide is formed which is removed by filtration. The solution is then again electrolyzed under the same conditions, when a further precipitate is formed and removed. The process may be repeated for the number of fractions desired. Examination of the two fractions shows that a rapid and quite complete separation of yttrium from erbium has been effected. (1,115,513, Nov. 3, 1914.)

### Ore Cooler

**Apparatus for cooling roasted ore** is shown in Fig. 7, being the invention of Robert W. Hanington, of Denver, Colo. It consists essentially of two concentric cylinders mounted on a hollow shaft supported in an inclined position. The inner surface of the outer cylinder and the outer surface of the inner cylinder are provided with Z-shaped flights which serve to catch the ore fed into the space between the two cylinders and distribute it over their surfaces during the rotation of the machine. Water is distributed over the outer cylinder from a launder supported above the cooler, and is sprayed over the inner surface of the inner cylinder through perforations in the hollow shaft. During the rotation of the machine the ore passes from the feed to discharge end due to the inclination of the cylinders. (1,101,433, June 23, 1914.)

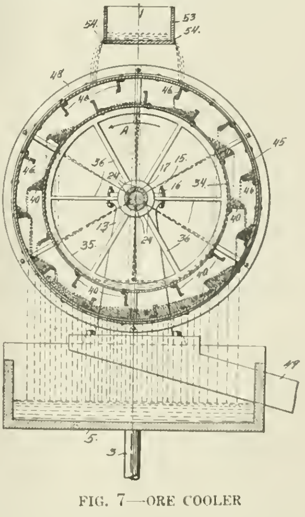


FIG. 7—ORE COOLER

## Zirconia, a New Refractory

BY H. CONRAD MEYER

Among the numerous so-called rare elements, zirconium has, to within the last few years, ranked as technically unimportant. The development of the electric furnace, requiring for its construction bodies having an extraordinarily high degree of refractoriness, has probably been an important factor in calling the attention of the electrometallurgist to the possibilities of zirconia.

In the year 1788, the German mineralogist, M. H. Klaproth, while engaged in the analysis of the mineral zircon, discovered that apparently 68 per cent of the mineral consisted of a very inert substance differing in its properties from all other substances known at that time, and which he ultimately determined to be the oxide of a new element. Having been first recognized in the mineral zircon, the name zirconium was proposed and ultimately adopted.

The element zirconium in the free state occurs in three forms: amorphous, crystalline and graphitic. It has a density of 6.4 in the crystalline form, with a melting point of about 2350 deg. C. As the element has no important use in its uncombined state at the present time, we will not dwell further upon its properties. It is not as rare as commonly supposed, having been determined by careful calculation to constitute 0.03 per cent of the lithosphere,[1] about as plentiful as the element carbon.

*Sources.*—At the present time there are only two known minerals which occur in sufficient quantities to be considered as commercial sources of zirconium. The first of these is the natural oxide zirconia; the second, zircon or the silicate. As zirconium oxide is generally the starting point for all zirconium compounds, the natural oxide is thus more eminently fitted as a commercial source than zircon. As found in nature, natural zirconia carries about 84 per cent of the pure oxide, with about 8 per cent silica and 3 per cent iron oxide. There are several methods in vogue for the extraction of the pure oxide, the best known being that of fusing the natural substance with sodium carbonate or hydroxide, thus producing sodium zirconate, which on being leached is hydrolized, forming soluble sodium silicate and insoluble zirconium hydroxide. The precipitate after thorough washing, can be readily converted into soluble salts by treating with any of the strong mineral acids.

*Refractory Properties of the Pure Oxide.*—Refined zirconia is a pure white substance, having a density of about 5 and a belting point of 3000 deg. C., according to Weiss. The first important use found for the oxide was to replace the calcium oxide cylinders used in the Drummond or so-called lime light. The great objection to the calcium oxide was its rapid deterioration, owing to its absorption of moisture and carbon dioxide from the air. Besides giving a more intense illumination, zirconium oxide was absolutely unaffected by moisture or any of the atmospheric gases.

Later, in 1880, R. von Welsbach impregnated loosely woven cotton or linen fabric with zirconium nitrate, securing a skeleton of zirconium oxide by incineration. The form of the fabric, thus perfectly preserved, became highly incandescent when heated in the flame of an ordinary Bunsen burner. Subsequent experiments proved, however, that thorium gave the same results at a much lower temperature. Therefore, it has almost entirely replaced zirconium for this purpose. These experiments of von Welsbach mark the inception of the incandescent gas mantle industry.

---

[1] Data of Geochemistry, F. W. Clarke, Bulletin 491, U. S. Geological Survey.

The next important application of the pure oxide occurred in 1897 in the Nernst light, developed through the behavior of certain refractory oxides, which, when heated to a high temperature, become excellent conductors of electricity and glow with an intense white light. This lamp consists essentially of a number of small rods or "glowers" composed of magnesia, zirconia and yttria. By a suitable heating device, the glower is raised to a temperature of 634 deg. C., at which point current begins to flow, raising the oxides to incandescence. As the quantity of zirconia used in the Nernst lamp is comparitively small, no great commercial application can be looked for in this quarter.

The remarkable heat-resisting qualities of zirconia at once commended it as a refractory of the first order. Its high melting point, low coefficient of expansion and low thermal conductivity, make it apparently the ideal lining for electric furnaces of the arc type. The pure oxide, owing to the comparatively high cost of extraction, is too costly a material for industrial uses on a large scale. Careful tests have shown, however, that natural zirconia is eminently fitted for such work and has only a slightly lower efficiency.

Very remarkable heat-resisting ware, such as crucibles, muffles, pyrometer tubes, combustion boats and resistance cores for electric furnaces, can be manufactured from pure zirconium oxide mixed with from 3 per cent to 10 per cent magnesia, using starch, phosphoric acid, glycerine or borates as binders. The ware is dried for several days at a low temperature and then fired in the electric furnace at a temperature ranging from 2000 deg. to 2300 deg. C. This ware is practically impervious to liquids, and is not affected by strong acids or alkali fusion mixtures.

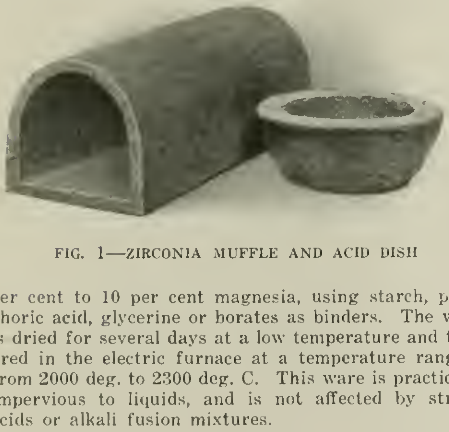


FIG. 1—ZIRCONIA MUFFLE AND ACID DISH

Owing to the extremely low coefficient of expansion, zirconia ware can be subjected to very sudden changes of temperature, such as plunging a red hot crucible in water, without the slightest danger of fracture.

The fusing point of tungsten alloys and the boiling point of pure iron, according to recent investigations,[2] have been successfully determined in zirconia crucibles.

The cost of the pure oxide for the manufacture of such articles as the foregoing and other ware requiring a maximum resistance to heat and corrosive action, is at the present time not prohibitive, as it can be readily prepared from the natural zirconia by the method already briefly outlined. An iron-free oxide can also be prepared, according to a recent process, at a low cost.[3] The pure oxide mixed with sufficient sodium silicate or phosphoric acid to form a plastic mass, affords a cement or lute capable of withstanding the severe temperatures of electric furnaces of either the resistance or arc type.

*Refractory Properties of Natural Zirconia.*—To compete with the various high-grade refractory bodies now used industrially, zirconia must possess certain superior properties lacking in these cheaper refractories, such as a higher melting point or greater resistance to chemical agencies. In other words, the initial cost of a zirconia lining, which is rather high as compared with, for example, magnesite brick, is more than offset by its high melting point, (3200 deg. F. to 3600 deg. F.), high resistance to corrosive slags, metals or metallic oxides, low thermal conductivity and low coefficient of expansion. All of these superior factors indicate the life of a zirconia lining to be of very much greater duration than the best natural refractory lining now available.

Actual working tests made on a Martin-Siemens furnace in a steel works at Remscheider, Germany,[4] using a zirconia-lined hearth, show that after four months of continuous operation at high temperatures, the hearth was still in good condition and would serve at least four months longer before renewal. Careful statistics compiled from these tests show a saving of 50 per cent in actual maintenance costs in favor of the zirconia lining over an ordinary refractory lining such as is generally used. No allowance was made for increased production and higher efficiency. Owing to the low thermal conductivity of zirconia (about one-half that of ordinary fire brick), it has been demonstrated in actual practice that a 2-in. lining is equivalent to 4 in. of chamotte.

The high resistance of this refractory to such metals and alloys as copper, steel, bronze and red brass, should commend its use in their metallurgy. Gaseous or molten fluorides affect it markedly, however, likewise bisulphates, but as there are only a few substances inert to such corrosive compounds, this can be hardly cited as a detrimental feature.

As a protective coating or paint for ordinary fire brick exposed to the destructive action of acid fumes or slags, zirconia should find a limited application.

A suitable bonding medium for such a purpose might be found in a weak solution of water glass or sodium silicate.

All bonding material must be used advisedly, as they naturally tend to lower the fusing point of the refractory. In lining furnaces or other metallurgical apparatus, natural zirconia can be mixed with water-free tar as a binder, in which case wooden forms are generally used. These are allowed to remain in place and consumed during the initial heat. The temperature should be raised very slowly at first to eliminate the volatile products in the tar, after which a temperature of at least 1400 deg. C. must be maintained for about 48 hours. Natural zirconia begins to fuse at about 1800 deg. C., and at 2000 deg. C. there is a noticeable volatilization of silica and other impurities.

In the manufacture of natural zirconia brick, muffles, crucibles and small articles of refractory ware, about 2 per cent of air-slacked lime as a binder has been used with success. In practice, a batch composed of 75 per cent 100-mesh zirconia, 23 per cent of 10 mesh, and 2 per cent of slacked lime, is worked into a plastic with a 3 per cent solution of 38 deg. Bé. sodium silicate. The bricks or ware are then pressed from this and allowed to thoroughly dry in a warm atmosphere. The procedure from this point on is the same as in the burning of ordinary refractories, except that a temperature of at least 1400 deg. C. is necessary to secure the proper vitrification.

As the density of zirconia is rather high (about 4.2), it has been suggested where imperviousness is not desired, that the incorporation of certain organic substances or volatile salts which would be destroyed during firing, thus producing small air cells, might serve to lighten the finished product without impairing its efficiency. Sawdust, cork dust or certain ammonium salts might prove of value for such aeration.

---

[2] Ruff, Lieferfeld & Bruschke, Zeit. anorg. Chem., p. 389, 1911.
[3] German patent No. 262,009.
[4] Private communication.

The low coefficient of expansion renders zirconia ware free from all danger of fracture due to sudden changes of temperature. In this respect it resembles fused silica ware.

The cost of zirconia as compared to certain artificial refractories produced in the electric furnace is considerably lower, which, in view of its remarkable properties, should commend it strongly to the furnace man or metallurgist.

Foote Mineral Company,
Philadelphia, Pa.

## The Analoid Method for the Determination of Manganese in Steel, Iron Ore and Slag

The Scientific Materials Company, of Pittsburgh, Pa., through its research department, has recently taken up the problem of standardization of analytical methods for iron and steel laboratories. The first method undertaken was the determination of manganese.

The method selected as basis is the "Walters" or "persulphate" method, as it was considered preferable for routine analysis to any other, and as its general scheme is being practiced in a majority of iron and steel laboratories.

This method in brief consists of dissolving sample in nitric acid, adding measured amounts of silver nitrate and ammonium persulphate, holding the solution at about the boiling point until the oxidation of the manganese to permanganic acid is complete and finally cooling and titrating with a standard solution of sodium arsenite.

In the analoid method all the good points of the Walters method are retained, the operations standardized and at the same time simplified, by the application of the "analoids."

An "analoid" is a tablet containing just the exact quantities of the proper reagents, which have been carefully tested and apportioned to give the very best result for a certain reaction in the method for which it has been specially prepared.

### Method for Steel and Wrought Iron

Sample: 0.1 grm. for percentages of Mn from trace to 1.10 per cent.

Place in a 6-in. by 1-in. test tube. Measure on to sample, with dispensing burette, 10 cc of 1.10 sp. gr. nitric acid (one part $HNO_3$ of 1.42 sp. gr. to four parts water). Place in boiling water in carbon boiler. When the solution is complete, without removing from boiler, add one 8-A analoid (silver nitrate). This will dissolve immediately. Add one 8-B analoid (ammonium persulphate). One minute from the time the pink color first appears, remove the test tubes from the boiler and place in water bath to cool. When at room temperature, wash into a 4-in. porcelain dish with 15 cc to 20 cc of water and add 3 cc of sodium chloride solution (5 grams per liter). Titrate with N/100 sodium arsenite solution* until the pink color is just discharged.

The addition of the sodium chloride solution is recommended as stated above, since it materially sharpens the end point.

### Method for Cast Iron, Pig Iron and All Slags

(For percentages up to 4 per cent.)

Sample: 1 grm. if from trace to 2 per cent Mn, or ½ grm. if from 2 per cent to 4 per cent Mn.

Place in a 300-cc beaker. Dissolve in 40 cc $HNO_3$ sp. gr. 1.20 (one part $HNO_3$ 1.42 sp. gr. to one part $H_2O$). Simmer until all soluble matter is dissolved. Dilute filter and make up to 250 cc, mixing thoroughly. With pipette take 25 cc, and run into a 6-in. by 1-in. test tube and proceed as before but add two 8-A analoids (silver nitrate) and two 8-B analoids (ammonium persulphate).

Titration: Rinse into a small conical flask, dilute to about 60 cc. Run in 3 cc sodium chloride solution and titrate with N/100 sodium arsenite until pink color is discharged.

Slags containing sulphides should be boiled three or four minutes after solution is complete, to insure all sulphur being oxidized. In dissolving, to prevent clotting, add first a little water and when boiling, add acid slowly. If any tendency to clot appears throw out sample and start another with more water.

### Method for Ores

Sample: 1 grm. if from trace to 2 per cent Mn, or ½ grm. of from 2 per cent to 4 per cent Mn.

Place in a 4-in. evaporating dish. Dissolve in 20 cc of HCl sp. gr. 1.18. Simmer until soluble matter is dissolved. Add 2 cc to 3 cc of hydrofluoric acid. Simmer until silicates are decomposed.

Add carefully 15 cc concentrated $H_2SO_4$. Evaporate to fumes of sulphur trioxide. Cool, dilute to 40 cc with water, and boil until all the soluble matter is dissolved. Filter and make up to 250 cc. Proceed exactly as for cast iron, etc.

### The Analoids

The matter of preparing suitable analoids was a far more difficult chemical problem than might at first be supposed. It was finally solved in the laboratory of C. H. & N. D. Ridsdale, the distinguished English iron and steel chemists.

The purity of the chemicals which enter into the analoids is first tested and the method of preparation is the same as employed in the dispensing of poisons, where very minute quantities are equally apportioned in each tablet.

The binders used in preparing the analoids preserve the reagents employed, so that they keep almost indefinitely.

The "analoid" method first embodies all the advantages of the "Walters" or "persulphate" method, but the number of operations has been decreased and at the same time the precision with which each operation is performed has been greatly increased by using analoids.

In this method, the measuring out and adding to the determination of an amount of silver nitrate solution is entirely eliminated. This operation took some time and as practised in many laboratories was done inaccurately and delayed the operation because the aqueous solution of silver nitrate cooled the determination.

Furthermore, the operation of first making the silver nitrate solution is entirely eliminated, which had to be done quite frequently on account of the unstableness of the solution.

The possibility of error in results by using a silver nitrate solution which should have been discarded, is eliminated and, of course, the waste incurred by constantly disposing of the old solution is also done away with.

In the analoid method the addition of an 8-A (silver nitrate) analoid, which instantly dissolves, completes this operation.

---

* The N/100 sodium arsenite solution is made up of 0.491 gram of $AS_2O_3$ dissolved in 2 or 3 grams of sodium carbonate and hot distilled water, cooled and then made up to one liter with cold distilled water. Standardize against a steel of known manganese content. The sodium chloride solution is used in standardizing. For a 0.1 gram sample the N/100 sodium arsenite solution should equal about 0.11 per cent manganese per c.c.

In the old method the next operation is the addition of ammonium persulphate. This was done either by adding a solution or by adding the slightly moistened salt. The solution method requires weighing, and new solutions must be made frequently and the unused portion of the old solution discarded, as it quickly spoils. Often the solution is used when it should have been discarded and results are correspondingly incorrect. Time is lost owing to the necessity of measuring and adding the solution and the reaction postponed on account of the cooling effect on the determination.

The dry-salt method requires the weighing of each addition if the analyst is exact, but ordinarily the measuring is done by spoon, which, of course, is not exact. The operation is what is known in the laboratory as sloppy, because of the spilling and the sticking of the salt to the sides of the container in which the determination is being made. To correct this, the wash bottle is used, which takes time and changes the dilution of the sample.

When oxidation seems to be complete, the sample is removed from the source of heat. Some chemists perform the above-mentioned operation when sample is removed from source of heat and trust that the heat of the solution will be sufficient to complete the reaction. This, however, is not in accordance with the work of the more careful analysts who hold the determination at 100 deg. C. until oxidation is complete.

By the analoid method, one 8-B (ammonium persulphate) analoid is added, which acts immediately, and one minute later the test tube is removed from the water bath and cooled.

From this point the analoid method is the same as the Walters method and is finished by titrating the permanganic acid with standard sodium arsenite.

The time required for one determination by the analoid method is about nine to ten minutes including weighing, and for ten determinations about twenty minutes. For a great number, the time required may be figured at one minute per sample for the weighing and a further allowance of twenty-four to thirty minutes made for the manipulation, on a lot of fifty samples. With the exception of the weighing, the time required by the other method, as usually practiced, is at least twice as great.

In the analoid method every sample is treated exactly in the same way, whereas if the same precision were reached by the old method, the time required would be many times greater. In practice precision has usually been sacrificed for speed.

By diminishing the number of operations, as is done by the analoid method, the amount of apparatus required is also diminished, which permits the chemist to keep much neater and better appearing hoods and work benches.

This method is conductive to more accurate and careful work on the part of the operator because of its neatness and the fact that the necessity of hurrying is eliminated.

The Scientific Materials Company is extending the application of the analoid method to other routine analyses in iron and steel laboratories.

## A New High-Pressure Gas Valve

In valves for high-pressure gas cylinders the safety features are very important. The valve must be free from leaks and easy to operate and it should last a reasonable time. The International Oxygen Company, of Newark, N. J., as a large shipper of oxygen and hydrogen in cylinders, experienced in the early days considerable trouble with valves. They found, for example, that the average valve, even though made tight at the start, would not remain tight under high pressure. This occasioned losses from leakage sometimes as high as 25 per cent of the contents of the cylinder. Moreover, the packing in the valves was a source of trouble and if made of an inflammable material, such as leather, would even be a source of danger. The International Oxygen Company finally decided to take up a systematic research to develop a valve that would meet all requirements. As a result of a long series of experiments they evolved a high-pressure stud valve which is admitted to be unique, embodying principles of design and construction which are entirely original and eliminating the various objectionable features which caused their early troubles.

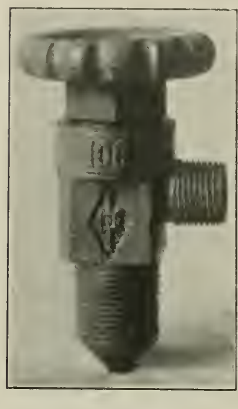


FIG. 1—HIGH-PRESSURE GAS VALVE

The I. O. C. stud valve can be used for pressures up to 2500 lb. It is specially recommended for oxygen, hydrogen, nitrogen and similar gases. It is made of noncorrosive metal throughout, no packing being used in any part. The body is forged tobin bronze, while the other parts are made of suitable metals which are noncorrosive to gases or to any weather conditions. Figs. 1 and 2 show the simple construction of the valve. Every part is accessible and if worn out can be easily replaced at little expense.

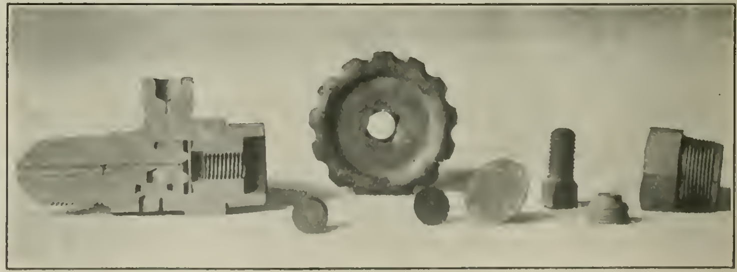


FIG. 2—SECTIONAL VIEW AND PARTS OF HIGH-PRESSURE GAS VALVE

The diaphragm is made of very tough and springy material that will withstand perfectly all the strain put upon it, without any possibility of its cracking or breaking even after many years of service. The diaphragm takes the place of packing material, and in this way the usual stuffing box is entirely eliminated. In the case of high-pressure oxygen gas, the studding box is extremely objectionable, as one must resort to the use of rubber, leather or similar inflammable materials.

The diaphragm is slightly concave, and is normally set away from the seat of the valve a sufficient distance to permit a full opening of the valve. It is not necessary, therefore, for the gas to raise the diaphragm; in this way all the gas from the cylinder can be used, down to atmospheric pressure.

An essential part of any high-pressure valve is its safety plug. In the I. O. C. valve this is an ingenious device which has received the approval of the Bureau of Explosives of the Interstate Commerce Commission. The plug is filled with fusible metal melting at, or below, the boiling point of water. It is provided with three passages, each in a straight line with the direct action of the gas in the cylinder to permit the outflow of the metal; is further provided with a hemispherical seat and a phosphor bronze disk. This safety plug is screwed into the body of the valve and forms a tight seat by compressing the phosphor bronze disk. No part of this plug projects beyond the body of the valve, this protecting it against breakage. The safety plug will not blow when submitted to the direct rays of the sun or any other atmospheric condition; but will blow when placed in a fire, before the expansion of the gas can do any damage to the cylinder.

This valve has been in use in the Newark works of the International Oxygen Company for a number of years and a great many valves are used by other gas manufacturers in this country and Canada. The valve has given entire satisfaction under all conditions of severe laboratory tests and of actual commercial service.

## A New Vacuum Pump for Vacuum Heating and Vacuum Filtration Systems

A novel vacuum pump has been put on the market by the Nash Engineering Company of South Norwalk, Conn., for use in connection with vacuum heating systems, vacuum filtration, or wherever air containing a large percentage of liquid has to be handled. The primary object of a vacuum pump in a heating system is to rapidly remove the air which is very detrimental to the efficiency of the system. The pump should do this without the necessity of introducing cooling water with consequent loss of heat. This is very effectively accomplished by the Nash hydroturbine.

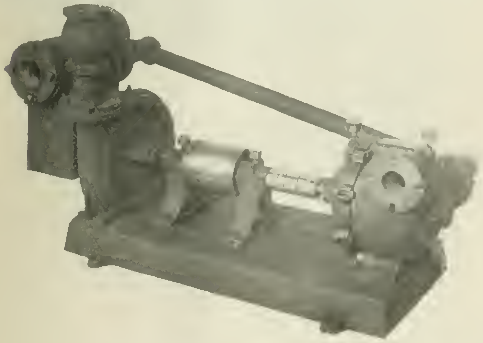


FIG. 1—HYDROTURBINE AND CENTRIFUGAL SET

Fig. 1 shows clearly the various parts. A Nash hydroturbine and Gould centrifugal are mounted in line on a cast-iron base. A separator is connected at the bottom to the centrifugal and near the top to the Nash pump. A check valve is placed on the outlet of the centrifugal.

The action of the outfit is as follows: As soon as the shaft is rotated the Nash hydroturbine produces a vacuum in the system, which draws water and air into the separator. The water falls to the bottom of the separator and is discharged by the centrifugal. The air is drawn from the top of the separator by the Nash pump.

As the amount of water handled varies, the centrifugal is made large enough to take care of the maximum quantity. When less water than this comes along the centrifugal continues to pump water until the separator is empty. The centrifugal then ceases to deliver water, but the check valve on the outlet prevents the vacuum from being broken.

As soon as the water has accumulated in the separator sufficiently to submerge the inlet, the centrifugal once more takes hold and pumps the water out.

The advantages of this simple combination are at once apparent. The water and air are handled separately in pumps specially designed for the purpose, the air in an air pump, the water in a water pump, which means greatly increased efficiency. The water may be delivered efficiently against a head without putting any back pressure against the air pump, which means a big saving in power as the air pump is of relatively large volume as compared with the water pump. It is possible to handle water containing dirt and abrasive material, as this all passes through the centrifugal, which is adapted for this service, and furthermore may be replaced at small expense if it finally is worn out.

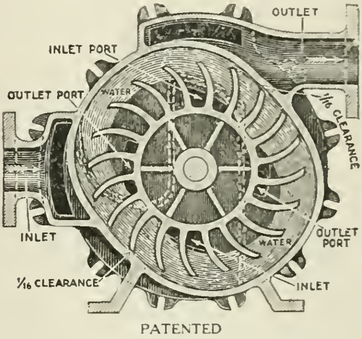


FIG. 2—CONSTRUCTION OF PUMP

An examination of Fig. 2, illustrating the interior of the Nash pump, shows the simple and efficient principle upon which it works and why it is specially adapted to the service described above.

The water follows the case, due to centrifugal force. Twice in a revolution the water recedes from the rotor, thereby leaving spaces between the blades into which air is drawn through the inlet ports. The water then surges back into the rotor, compressing and delivering the air through the outlet ports. The water seal prevents leakage. The water is used continuously. The suction is uniform. The pressures on the shaft due to compression are balanced. There are no valves or loose moving parts. The rotor is the only moving element and is fitted with ample clearance.

The large volume of air handled by the Nash pump keeps the centrifugal primed and free from air, which means that it works at its highest efficiency. The large volumetric capacity also makes it possible to produce a vaccum when handling extremely hot water. Under this condition the action of the pump is as follows:

The vacuum rises until the point is reached where the water becomes steam at the existing temperature. The Nash pump takes the steam away as fast as formed. The steam is drawn into the pump under a vacuum and is compressed by the pump and delivered at atmospheric pressure.

As the steam is compressed some of it condenses and is delivered as water.

The reliability of this outfit is one of its strongest points, as both pumps have only one moving part, running with a clearance. There are no valves or piston packing to require attention.

The machine shown in Fig. 1 is arranged for belt drive. It can also be built for direct connection.

## A New Water Still

The following article describes a new water still involving several interesting novel features. It is built by the A. P. Link Manufacturing Company, 212 Thirty-ninth Street, Brooklyn, N. Y.

The still is shown diagrammatically in Fig. 1, with the boiler at the left and the condenser at the right. An outside view of the still is shown in Fig. 2.

The apparatus is made entirely of copper, heavily tinned with pure block-tin, and has an easily removable sediment receiver which can be conveniently placed inside of the boiler where it keeps the water in constant circulation from the outside towards and up through the center, depositing all the sediment in a sediment cup, thereby preventing the settling of any sediment and any encrustation along the boiler surfaces. By these means also a larger steaming surface is obtained than can be produced with a flat boiling surface only.

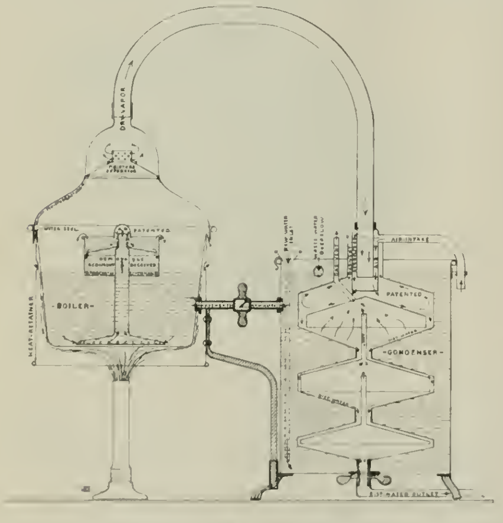


FIG. 1—DIAGRAM OF WATER STILL

The water in the boiler is constantly kept at its proper level by means of a very simple hinge check valve, which permits the water to flow from the condenser to the boiler (from right to left in the diagram) but not in the opposite direction, so that it is impossible for undistilled water to pass over to the condenser.

The water before entering the boiler is pre-heated by the steam from the boiler and can be kept at any desired temperature so as to free the water from a great amount of ammonia and other gases before it is admitted to the boiler.

Another novel feature in the boiler is the provision which has been made to separate moisture (which is more or less contaminated) from the splashing bubbles which are projected against the inner surfaces of the cover or other parts of the boiler so that this moisture cannot be entrailed into the condenser whereby naturally the distilled water would be rendered impure to a certain extent. This feature has also been well tested out and found very successful in eliminating all moisture from the vapors before they leave the boiler cover. Such moisture is returned to the boiler immediately by its own gravity, and without loss of heat units.

The vapors arriving at the condenser neck can be permitted to syphon an abundant amount of free air which is sterilized around the steam pipe proper, within the condenser neck. The air is finally mixed with the steam and water while projected against the walls of the condenser, which are surrounded by water. The water vapors are immediately condensed while the remaining gases are liberated according to their specific gravity in a discriminating manner at various points, which is accomplished without loss of water vapor. This air syphon is made use of when well aerated water is desired for drinking purposes. If non-aerated water is desired, all that is necessary is to stop up the air intake, whereas the elimination of all the gases is never interfered with.

The second venting tube is at the same time an indicator for the operator if the water in the condenser should become too hot. In this case this vent tube shows a slight escape of steam, so that by this means the proper temperature of the condensing water can be easily obtained, or the apparatus so operated as to eliminate any and all gases according to the temperature at which the condensing water is being kept.

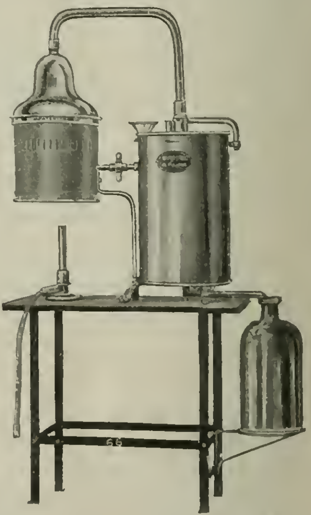


FIG. 2—OUTSIDE VIEW OF WATER STILL

It is obvious that with this apparatus, even very polluted water can be distilled to absolute purity. The distilled water leaving the condenser at the bottom is cool, practically at the same temperature as the raw water fed through the inlet.

The raw water from the inlet is always projected against the lowest part of the condenser, whereby the temperature of the water on top of condenser can be constantly kept at the desired degrees to accomplish the desired results.

All parts of the still are easily accessible, can be readily taken apart and cleaned and re-assembled without delay, and without use of any tools or experience. The whole apparatus consists of *only five parts*, boiler, condenser, sediment receiver, cover, and vapor pipe. It is portable and can be readily set up and operated upon any shelf, a table, a stand, a stove, or wherever convenient or it can be set up permanently and connected with any gas, water and steam supply.

# A New Electrical Long-Distance Transmitting Indicating and Recording System

A new electrical long-distance transmitting indicating and recording system is being placed on the market by The Bristol Company, Waterbury, Conn. In these instruments Bards patent long-distance induction-balance movements are employed as especially developed for this purpose by the Sangamo Electric Company. Bristol recording instruments, when equipped with these electrical transmitting systems, are capable of producing automatic and continuous records of pressure, liquid levels, temperatures, mechanical motions, etc., at long distances, even many miles from points at which the transmitters are located.

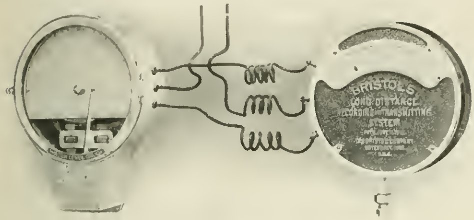


FIG. 1—STANDARD UNIT OF TRANSMITTING AND RECORDING INSTRUMENT

Fig. 1 shows a standard unit of these transmitting and recording instruments, including the transmitting indicator for installation at the point where the pressure or temperature, etc., is measured, and the receiving recorder which is installed at the remote point where it is desired to have the printed record produced.

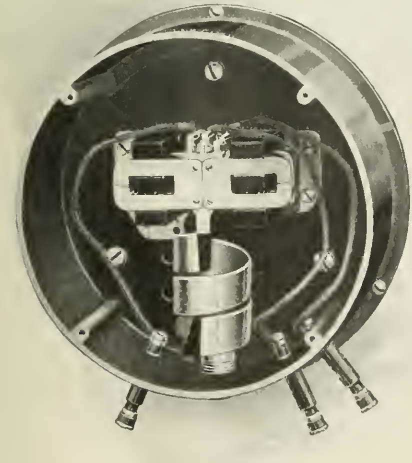


FIG. 2—INTERIOR OF TRANSMITTING INSTRUMENT

The two instruments are shown connected by three wires, one of which is connected in the manner indicated to a source of alternating current, as for instance, a lighting circuit.

This long-distance system is particularly well adapted for use under ordinary operating conditions because of its simplicity of construction. There are no sliding or make-and-break contacts employed, and the effects of variation of temperature or resistance along the circuit are negligible. The recording instrument may be installed many miles distant from the measuring and transmitting device. For instance, if 110 volts and No. 14 copper wires are used, the recorder may be located thirty miles from the transmitter, or if No. 12 leads are used the recorder can be installed forty miles or more from the transmitter. The transmitting device is mounted in moisture-proof case, and can be installed outdoors if necessary, as, for instance, on the bank of a reservoir.

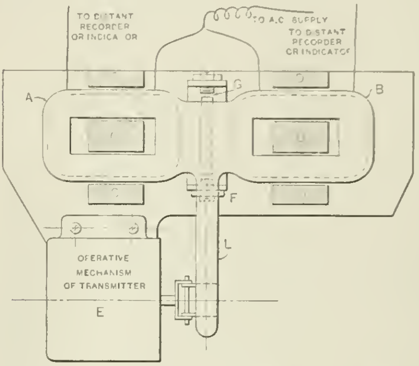

TO DISTANT RECORDER OR INDICATOR
TO A.C SUPPLY
TO DISTANT RECORDER OR INDICATOR
A
B
G
C
D
F
L
OPERATIVE MECHANISM OF TRANSMITTER
E

FIG. 3—FRONT OUTLINE DIAGRAM OF TRANSMITTING DEVICE

One of the first outfits of these instruments was installed at Peoria, Ill., to indicate at the central station the steam pressure at the end of the steam-heating main, and the superintendent of the electrical department of the Central Illinois Lighting Company, by whom this was used, has made the following statement: "In regard to this particular outfit, which has been in service more than four years, two other systems were installed by us on the strength of the success by the first system, and all have given very good service." Over a dozen other sets of this equipment have also been in successful service for more than two years.

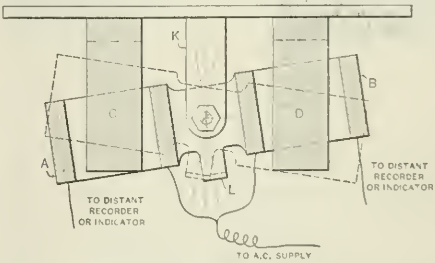

K
B
C
D
A
L
TO DISTANT RECORDER OR INDICATOR
TO DISTANT RECORDER OR INDICATOR
TO A.C. SUPPLY

FIG. 4—TOP OUTLINE DIAGRAM OF TRANSMITTING DEVICE

The fundamental principle of the Bristol long-distance transmitting and recording system is that of the induction balance. The transmitting instrument and the receiving instrument are each equipped with two pairs of coils arranged to swing in a horizontal plane over iron cores. Fig. 2 shows the interior of one of the transmitting instruments. In this instrument the helical form pressure tube and the electrical transmitting device are shown in the operating position.

Figs. 3 and 4 are detailed front and top outline diagrams of the transmitting device, which is similar to the receiving device.

The complete outfit consists of two pairs of mechanically balanced solenoids arranged to swing horizontally back and forth over the ends of soft iron cores and connected in parallel to an alternating-current circuit. One pair of the solenoids is used for the transmitting instrument, the other pair for the receiving instrument. Front view, Fig. 3, of the transmitter shows one pair of the solenoids A and B on spools connected together and supported on a shaft, the ends of which rest in jewel bearings at G and F and free to swing back and forth over laminated soft iron cores C and D. The top view, Fig. 4, shows the solenoids A and B of the transmitter in section and by the dotted outline the position to which the solenoids may swing is also indicated.

A similar pair of balanced solenoids is placed in the receiving recorder or indicator at the distant point. When the solenoids A and B of the transmitter and receiver are connected in parallel to an alternating-current circuit and the transmitter coils A and B are held in some certain position by the operating mechanism located at E (water level gauge, pressure gauge, thermometer, etc.), the relative amounts of current flowing in solenoids A and B will depend on their positions on the iron cores C and D due to the inductive effect of same.

At the receiving instrument the other pair of solenoids are mechanically balanced and free to take an angular position which will be the same as that of the transmitter since the flow of current will be the same in the corresponding solenoids of the receiver as in the transmitter. If the angular position of the pair of solenoids at the transmitter is changed by the operating mechanism thus moving one of the solenoids off and the other on to the iron cores, increasing the inductance in one solenoid and diminishing it in the other, the flow of current will be proportionately increased in one coil and diminished in the other. The variations of current at the distant receiver will correspond with the variations at the transmitter, and cause the pair of solenoids of the receiver to seek a position of balance which will be the same as that of the solenoids of the transmitter.

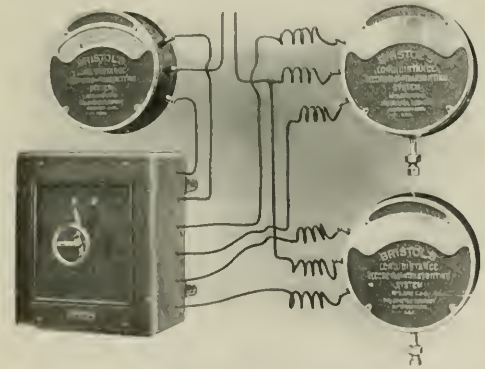


FIG. 5—COMBINATION OUTFIT OF TWO TRANSMITTERS AND ONE RECEIVING INDICATOR

In the transmitter the operating mechanism is linked directly to the balanced solenoids by means of an arm L. In the receiver the recording pen or the indicating pointer is connected to a similar arm through a simple and practically frictionless multiplying mechanism.

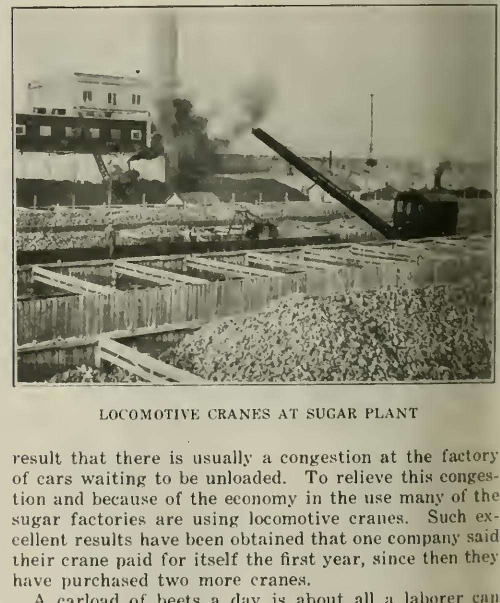
Various combinations of transmitting and receiving instruments of either indicating or continuous recording type may be furnished. Fig. 1 illustrates the standard equipment including a transmitting indicator and a receiving recorder, but it is possible to furnish the transmitter and receiver in either the indicating or recording type. Fig. 5 shows a combination outfit including two transmitters and one receiving indicator connected with a two-point rotary switch so that readings may be obtained with the indicator of the pressures, temperatures, etc., from either of the transmitters.

A great variety of applications for this apparatus will arise owing to its flexibility and extreme simplicity.

## Locomotive Cranes

The accompanying illustration shows in an interesting manner the efficient handling of bulk materials at a beet sugar factory by means of locomotive cranes. One of the cranes is being used to place coal in bunkers above the power house, while the other is unloading sugar beets from cars into the beet bin.

The beet harvest usually does not begin until about the middle of October and then the farmers try to deliver their beets before cold weather sets in, with the result that there is usually a congestion at the factory of cars waiting to be unloaded. To relieve this congestion and because of the economy in the use many of the sugar factories are using locomotive cranes. Such excellent results have been obtained that one company said their crane paid for itself the first year, since then they have purchased two more cranes.



LOCOMOTIVE CRANES AT SUGAR PLANT

A carload of beets a day is about all a laborer can unload by hand, while three men and a crane will unload from three to four cars an hour. In addition to the saving effected the crane does its own switching of cars so that rapid unloading is greatly facilitated. The crane in the foreground is using the special beet fork built so as not to crush the beets when handling them. Beneath the beet bins there are sluices to allow the beets to be transported to the factory by a rapid current of water.

Just before the picture was taken the farther crane loaded two 40-ton cars with coal from a reserve pile in twenty-five minutes. It then brought one of them around to the power house and placed the coal in elevated bunkers as shown. It also handles beets and limestone and is otherwise generally useful around the factory. The picture was taken at the plant of the German American Sugar Co. at Bay City, Mich., the locomotive cranes being made by the Industrial Works of the same city.

## Automatic Sampling of Mill Pulps

The automatic sampler described in this article is the design of Mr. Elmore and is being built by Messrs. F. W. Brackett & Co., Ltd., Colchester, England. The construction of the Elmore sampler is shown in the adjoining illustration.

It is to be noted that the sampler can be set with driving shaft at any angle in relation to the launder conveying the pulp to be sampled. By simply sliding the adjustable arm on the center pin, the machine is at once adapted to various widths of launders.

The sampler is put into operation by motion imparted through a round belt on the grooved pulley *Q* which is keyed to the shaft *P;* this in turn rotates the worm engaged with the worm pinion. This worm pinion operates an eccentric (not visible on the illustration) which reciprocates the pawl *R* causing the main ratchet wheel *O* to advance one tooth at a time. Thus the main ratchet wheel *O* is caused to rotate slowly.

To the upper face of *O* a toothed segment *N* equal to about one-sixth of the periphery of *O* is securely attached, the teeth of which are of the same pitch as those of the worm pinion. By the slow rotation of the main ratchet wheel *O* the segment *N* gradually approaches the worm pinion and engages with it, which immediately results in the quick movement of *N* and *O;* and as these carry the pin *E* to which is attached the sampling cup and discharge pipe *H*, it follows that during about five-sixths of each revolution (the non-sampling period) the main ratchet wheel *O* is moving at a very slow rate, whereas, for the other one-sixth of the revolution (the sampling period) the rate of movement is high, and the sampling cup thus cuts through the whole stream of pulp at a perfectly uniform rate of speed, and always at the same relative angle, during the whole period of sampling.

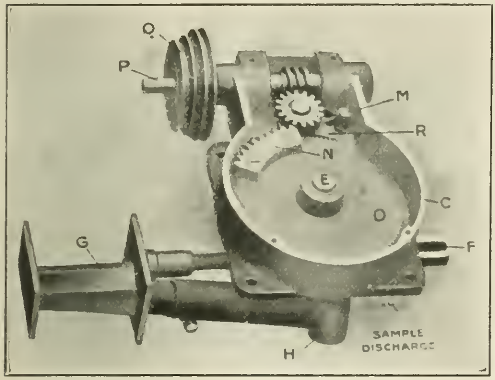


FIG. 1—AUTOMATIC SAMPLER

All the bearings and moving parts are enclosed in a substantial outer casing *C* covered with a dust-tight lid thus forming an oil bath, and providing perfect lubrication, minimizing wear and tear, and insuring continuity of working.

## Personal

Messrs. **Ernest Bamberger, Duncan MacVichie** and **H. L. Lambrecht** have been appointed by the United States District Court as appraisers of the tangible assets of the Ohio Copper Co.

Mr. **H. J. Baron**, manager of the Mexican Chemical Co., Chihuahua, Mexico, spent ten days in Denver last month in the course of a business trip to the States.

Mr. **Fred W. Bradley**, president of the Bunker Hill & Sullivan Mining Co., was tendered a reception recently at Kellogg, Idaho, at which he spoke enthusiastically regarding the development of the dry chlorination experiments that have been under way for some months past.

Mr. **T. H. Davis** has resigned his position as vice-president and general manager of the Rahway Chemical Co., of Elizabeth, N. J., and will manage the new plant of the Rahway Coal Tar Products Co., which will be in operation at Rahway, N. J., early next year. The new company is controlled by Merck & Co., of New York.

Mr. **Philip DeWolf**, chemical engineer, of Bristol, R. I., left for Memphis, Tenn., to investigate the possible local production of potassium salts, the supply of which to this country from abroad has been seriously curtailed since the beginning of the European war.

Mr. **J. C. Farrant**, European representative of the Hardinge Conical Mill Co., is a British prisoner at the Doeberritz detention camp near Berlin.

Mr. **H. C. Hoover**, who has been so prominent in the relief work in Europe since the opening of the war, is engaged in administrating relief measures in Belgium.

Mr. **A. J. Hoskin**, of Denver, has been in the gold mining districts of Georgia on professional business.

Mr. **John L. Malm** has returned to Denver from Kellogg, Idaho, where he is engaged in consulting metallurgical work for the Bunker Hill & Sullivan Mining Co. He expects to resume his duties at Kellogg after a brief absence on other professional duties.

Mr. **A. M. Plumb**, of the technical staff of the American Zinc Ore Separating Co., has been transferred from Denver to Platteville, Wis., where he will be engaged in a consulting capacity on the separation of zinc ore at the mill of the Wisconsin Zinc Co.

Prof. **Robert H. Richards** will be tendered a complimentary dinner at the Copley-Plaza Hotel, Boston, on Monday evening, December 7, "in recognition of his fifty years as a devoted Tech man and in expression of the respect and affection in which he is held by the Corporation, Faculty and Alumni of the Massachusetts Institute of Technology."

Mr. **James E. Russell** has been appointed assayer in charge of the United States assay office at Deadwood, S. D.

Mr. **Peter J. Weber**, city chemist of the city of Milwaukee, has resigned to accept the management of the American Metal Products Company of Milwaukee.

Mr. **Robert E. Wilbur** has been appointed assistant to the general manager of the Bethlehem Foundry & Machine Company.

## Digest of Electrochemical U. S. Patents

Prior to 1903.

*Arranged according to subject-matter and in chronological order.*

*Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.*

*Electroplating* (Continued)

626,330, June 6, 1899, Carl Luckow, of Cologne-Deutz, Germany.

Relates to making peroxide of lead, and consists in electrolyzing a solution containing, say, $1\frac{1}{2}$ per cent of a mixture of ninety-nine and one-half parts by weight of sulfate of sodium and five-tenths part by weight of chlorate of sodium, using electrodes of lead. The current density should be $\frac{1}{2}$ amp per sq. decimeter at about 3 volts. To facilitate the reaction and to keep the electrolyte in motion, air is carefully blown in during the process.

629,070, July 18, 1899, Pompeo Garuti and Riccardo Pompili, of Naples, Italy.

Relates to generating oxygen and hydrogen by the electrolysis of alkaline hydroxide solutions, and refers to his prior patent No. 534,259, on which the present patent is an improvement. The improvement consists in perforating the lower part of the insulated metal diaphragm with many small holes, or not more than 1 mm diameter, which prevents any gas escaping from one side to the other, and reduces the electrical resistance of the cell. The electrodes do not extend below the upper row of holes in the diaphragm.

630,246, Aug. 1, 1899, Frank S. Loeb, of New Kensington, Pa.

Relates to preparing aluminium for electrodeposition. The aluminium is first cleaned of any dirt, grease, etc., and rinsed in hot water. It is then immersed in dilute hydrofluoric acid, containing 25 cu. cm to 2 liters of water, until hydrogen gas is freely evolved; it is then removed and at once immersed in a "quicking" solution composed of 50 gr. of mercury dissolved in 100 cu. cm of strong nitric acid, this being added to 2 liters of water, and 30 gr. of potassium cyanide added; about five seconds immersion is sufficient; it is then reimmersed in the hydrofluoric acid until hydrogen is evolved, and then transferred to an electroplating bath. For copper plating, the following electrolyte is used: 8 oz. of copper acetate is made into a thick paste with water, then add 8 oz. of sodium carbonate dissolved in 2 qt. of water. In a separate vessel, dissolve 8 oz. of sodium bisulfide in 2 qt. of water, and add this to the copper acetate solution; then dissolve 6 oz. of potassium cyanide in 3 qt. of water, and add to the previous mixture, then add 5 qt. of water, bringing the volume to 3 gal. The bath should be used hot, about 130 deg. to 180 deg. F. Directions are also given for making electrolytes for depositing brass and silver.

647,858, April 17, 1900, Eduard Mies, of Büdesheim, Germany.

Relates to preparing aluminium to receive electrolytic deposits of other metals. The aluminium is heated for about five minutes in a boiling solution of phosphate of sodium and sulphate of magnesium, slightly acidulated with sulfuric acid, and then washed and then immersed in the ordinary electrodepositing baths as cathode and electroplated. The solution containing the phosfate of sodium, etc., probably corrodes or etches the surface of the aluminium, enabling the electrodeposited metal to adhere firmly.

653,715, July 17, 1900, Jean Theodore Van Gestel, of New York, N. Y.

Relates to an apparatus for producing a water-repellent surface on cloth or similar fabric, by immersing the cloth in a tank of water through which an electric current is passing, and then passing the wet cloth between one or two pairs of traveling metallic belts, the first pair so connected electrically that a current passes through the cloth in one direction, thereby producing a water-repellent surface on one side, and the second pair so connected electrically that the current passes through the cloth in the opposite direction, thereby producing a water-repellent surface on the other side. The traveling belts consist of upper and lower horizontal belts, each made of pieces of metal united with hinge joints, zinc being used as the anode, and copper for the cathode. The belts of each pair are supported on polygonal rolls driven by link chains and gearing, electrical contact being made with the belts by rollers for the upper belt and supporting pressure surfaces for the upper side of the lower belt. The lower side of each lower belt travels through a tank containing water which serves to wash off any impurities that may have collected thereon. The belts may be covered with a layer of cotton cloth to prevent short-circuiting. A pair of rubber rolls remove any surplus water from the cloth after treatment. (See patent 653,716.)

653,716, July 17, 1900, Jean Theodore Van Gestel, of New York, N. Y.

Relates to rendering cloth and similar fabrics waterproof and to setting the dye therein. The cloth is immersed in a solution of a metallic salt or salts and then subjected to the action of the electric current which causes an oxid of the metal to be formed in the interstices of the fabric. In fixing a dye the metallic salts are applied to the fabric either with the dye, or to the already dyed fabric as above described. For white goods a soluble salt of any suitable metal that will produce a white oxid, such as aluminum, is used, while for dark goods a soluble salt of a metal that will produce a dark oxid, such as iron, is used; and for goods of other colors, the soluble salt of a suitable metal such as will not change the color, may be chosen in accordance with well-known coloring properties of metals. The apparatus used is substantially the same as in patent No. 653,715.

## Book Reviews

**The Cleaning of Blast-Furnace Gases. By Frederick H. Wagner.** 168 pages, 58 illus. Price, $2. New York: McGraw-Hill Book Company, Inc.

A very timely work, in view of the fact that the subject is continually claiming increased attention. The chapters deal with the theory of condensation and cooling, dry dust catchers, wet cleaning, final cleaning, operative plants in America, and the storage of gas. These are all admirably handled except the theory of cooling and condensation, which contains too much of the academic theories of Dr. W. Feld. The four deductions on page 14 regarding infinite volume and infinite heat capacity of certain mixtures of gas and water vapor are neither pertinent, useful, nor instructive. The other chapters are all commendably good.

**Fuel: Solid, Liquid, and Gaseous. By J. S. S. Brame.** Octavo (14 x 22 cm.), 372 pages, 70 illustrations; price $3.50 net. New York: Longmans, Green & Co. London: Edward Arnold.

The author is lecturer on fuel at the Royal Naval College, Greenwich, and this volume is intended primarily to consider fuels in their relation to power, but their application to other purposes has not been omitted. It is intended primarily for engineers and technical men to whom the production of power is of importance.

It is a very satisfactory and useful book. The author discusses the composition, properties and calorific values of the different fuels in a masterly manner, which is commendably scientific as well as highly practical.

The only serious slip found was that the author seems unaware that the specific heats of gases at high temperatures are now known with fair accuracy, rendering possible satisfactory calculations of maximum flame temperatures. Using the old specific heats, which lead to impossibly high temperatures, he properly brands the results as absurd, and then dismisses the whole subject. The book would be improved by a short chapter on this topic.

The burning of coal dust is not given as much prominence as its successful applications in America to cement and metallurgical furnaces would warrant.

Aside from these two items the work is very well written, and as a whole it is strongly recommended to all interested in fuels and their investigation.

TN
1
C45
v.12

Engin.

Chemical engineering

ENGIN STORAGE

PLEASE DO NOT REMOVE
CARDS OR SLIPS FROM THIS POCKET

UNIVERSITY OF TORONTO LIBRARY